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Experimental Research on Instability of Second Kind of Shock-Heated Xenon Plasma in Shock Tube. II. Dynamics of Relaxation Flux Zone Behind Shock Wave Front

927J0258B St. Petersburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 1, Jan 92 pp 76-82

[Article by G. K. Tumakayev, Z. A. Stepanova and P. V. Grigoryev, Physical Technical Institute imeni A. F. Ioffe, Russian Academy of Sciences, St. Petersburg]

[Abstract] The first part of this study (G. K. Tumakayev, et al., ZhTF, Vol 61, No 5, pp 33-39, 1991) was devoted to research on evolution of the process of periodic change in the intensity of radiation of shock-heated plasma during its propagation along the low-pressure chamber of a shock tube. In this new part of the study it is established that in each oscillatory cycle of an autowave process (second type of instability of shock-heated xenon plasma) the relaxation zone, its extent, structure, as well as the maximum attainable level of intensity of radiation of equilibrium plasma in the flow behind the shock wave zone, experience considerable changes. In the resonance region of an autowave train with an unchanged intensity of the incident shock wave (M equal to about 12 +/- 0.1) the relaxation time of the ionization process with a frequency f about 12.6 kHz changes from 16 to 24 μs and the intensity of the plasma radiation in the equilibrium zone of the flow varies in the range +/- 40 percent. The results contradict prevailing concepts concerning the kinetics of ionization of monatomic gases in the flow behind a shock wave front. Figures 6; references 8: 4 Russian, 4 Western.

Nonlinear Self-Consistent Theory of Free Electron Lasers. Induced Radiation of Electrons Oscillating in Buckets

927J0245C Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 37 No 5, May 92 pp 651-659

[Article by V. V. Kulish and A. V. Lysenko, Sumy Physical Technological Institute; UDC 537.86+621.373]

[Abstract] This article is a continuation of previous work by V. V. Kulish (UFZh, 36, No 9, pp 1318-1325) and V. V. Kulish, et al. (IBID., No 10, pp 1485-1492); all the earlier notations and terminology are retained in this article. The previously proposed averaged kinetic equation method is used in solving the problem of induced radiation of electrons oscillating in buckets. The possibility of realization of two mechanisms of this phenomenon is demonstrated: transient and trapped. It is explained that the dynamics and character of the radiation processes differ considerably in the two cases with respect to the nature of transpiring of the radiation process and a series of physical characteristics. By using these differences it is hoped that it will be possible to identify the nature of the observed physical mechanism. If both mechanisms are operative simultaneously, as is most probable, measurements of the radiation parameters will make it possible to interpret the picture of "hot" nonlinear processes transpiring in the region of interaction of isochronal free electron lasers, for example, to clarify the relation between trapped and untrapped electrons and to study the dynamics of these processes along the length of the instrument. The induced radiation mechanism described in the article seems promising as a working basis for a new method for "hot" interpretation of relativistic electron beams in the interaction region of some types of free electron lasers. Figures 3; references 14: 12 Russian, 2 Western.

Nonequilibrium Boiling of Metal Bombarded With High-Density Electron Beam in Kilojoule Pulse Treatment With Pulsed High-Density Electron Beam

937J0005A Moscow DOKLADY AKADEMII NAUK in Russian Vol 323 No 4, Apr 92 pp 667-672

[Article by D.I. Vaysburd and S.V. Georgiyev, Tomsk Polytechnic Institute imeni S.M. Kirov; UDC 539.12.04]

[Abstract] Boiling of solid materials and specifically metals during their bombardment with a pulsed high-density electron beam was studied in an experiment; this process being characterized by a very high energy content. The difficulty of reaching the boiling threshold without prior brittle fracture was avoided by ensuring a sufficiently fast relaxation of mechanical stresses and thus raising the energy threshold for brittle fracture appreciably. Buildup of acoustic dynamic breaking stresses, usually relaxing within 1-10 μs, was altogether prevented by bombarding the metals with pulses of 0.1-1 ms long duration. Much faster plastic than thermal relaxation of quasi-static stresses was relied upon, quasi-static stresses being produced as a consequence of a nonuniform bombardment energy distribution and their thermal relaxation proceeding slowly because of the sluggish thermal diffusivity of metals. Three pure-grade metals featuring excellent plasticity characteristics were, accordingly, selected for the experiment: Cu, Al, Ni. Tests were performed on 2-4 mm thick disks 95 mm in diameter. Each specimen was bombarded only once with a 0.3-0.35 MeV electron beam having a 15 mm radius, in one pulse. Enough specimens were made available for varying the beam current density over the 3-7 A/cm^2 range, the energy in a pulse over the 0.1-2.0 kJ/cm^2 range, and pulse duration over the 0.1-1.0 ms range. The electron beam current was measured with a Faraday cylinder and Rogowski loops, its radial distribution was measured with a set of metal taps. The electron energy spectrum was measured by superposing the oscillograms of current pulses on the oscillograms of accelerating voltage. The profiles of 1-400 mm deep craters in the specimens were measured by two independent methods, under a microscope and with an IZV-3 altimeter. The loss of mass M was then calculated by integrating the product of crater profile h(r) times density of the material, it also having been measured independently by weighing a specimen before and after bombardment. The mechanical recoil momentum P of specimens was measured with a ballistic pendulum. The results reveal: 1) a rather smooth monotonic dependence of the loss of mass M and of the mean crater radius R on the duration of the bombardment pulse and on the mean dose of absorbed energy; 2) a nonmonotonic dependence of the recoil momentum P and of the mean velocity V = P/M of vapor particles leaving a specimen on the duration of the bombardment pulse and on the dose of absorbed energy; 3) a more mildly nonmonotonic but not quite smooth monotonic dependence of the relative loss of mass M/W on the duration of the bombardment pulse. An analysis of the heat balance data indicates that the principal mechanism of vapor ejection is nonequilbrium boiling, inasmuch as equilibrium boiling would have been characterized by a much smaller loss of mass and its linear dependence on the duration of the bombardment pulse. For a validation of this hypothesis, nonequilibrium boiling of a metal under given conditions is treated as a typical problem in nonlinear physics and analyzed accordingly. The laser analogy being more appropriate here than an analogy to two-fluid Landau quantum hydrodynamics of superfluid helium-4, a "hypothetical lasing" scheme is selected where the 0-3 transition most accurately simulates the pumping of a metal to heat it up to the boiling state. The heating period prior to the appearance of bubbles is treated as "dead" time, whereupon the accumulation of vapor in bubbles forming at the metal surface and in bubbles forming within the metal bulk is calculated by by solving the appropriate system of equations of mass balance. Article was submitted by Academician G.A. Mesyats on 28 January 1992. Figures 3; references 13.

Heating of Dense Plasma by Ultrashort Laser Pulse With Anomalous Skin-Effect Mode

927J0279D Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 101 No 6, Jun 92 pp 1808-1826

[Article by A. A. Andreyev, Ye. G. Gamaliy, V. N. Novikov, A. N. Semakhin, and V. T. Tikhonchuk, Institute of Physics imeni P. N. Lebedev at Russian Academy of Sciences]

[Abstract] Processes in a superdense plasma following absorption of pulsed laser radiation by such a plasma in the anomalous skin-effect mode are analyzed theoretically, considering that the rate of plasma heating is determined by the balance between the rate of energy input depending on the absorption coefficient and the rate of energy loss depending foremost on the electronic component of thermal conductivity. Inasmuch as the motion of electrons near the absorption region is collisionless and that the skin depth is much smaller than the mean free path for electrons, heat transfer can be treated in the kinetic approximation and absorption of laser radiation can be described in terms of a special boundary condition for the distribution of electrons in a semibounded plasma. Analytical and subsequent numerical solution of the equation of plasma heating kinetics for the rate of plasma heating rate upon normal incidence of an ultrashort laser pulse yield are compared with earlier estimates of the maximum plasma heating rate in complete absence of energy losses and the minimum plasma heating rate in the classical case of collisional heat conduction. The results indicate that incidence of a high-intensity ultrashort laser pulse such as a 0.25 μm radiation pulse of 100 fs duration and higher than 10^5 TW/cm^2 intensity will deform the electron distribution in the skin layer near the plasma boundary into an anisotropic non-Maxwellian one featuring a deficit of very slow and very fast electrons and a positive derivative of the distribution function with respect to the longitudinal electron velocity. Such a transition from a normal skin effect to an anomalous one will result in additional radiation absorption and suppression of heat conduction. Additional radiation absorption can, in turn, give rise to a secondary instability with an attendant transition to a turbulent state and an anomalous increase of the electrical resistance so that heat transfer will be further suppressed and the plasma heating rate will vastly exceed its estimate based on the classical theory. Figures 9; references 20.

Flow in Circulation Loops of Gas Laser

937J0006A Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 63 No 1, Jul 92 pp 38-43

[Article by A. I. Zhidovich, L. G. Zhukhovitskiy, and I. G. Osipyan, Scientific Research Institute of Nuclear Problems at Byelorusian State University, Minsk; UDC 621.373.826]

[Abstract] A basic problem in the design of gas lasers is design of a closed loop for circulating and the fan driving the active gaseous medium through it, a radial fan with a sheathed annular blade ring on a large hub having already been found to be most suitable. An apparatus for gas flow visualization is described, this experimental method of optimizing the circulation systems for gas lasers being not only comprehensive and very effective, but also simple. It is based on the analogy to hydraulic flow and is flexible for selection of appropriate models. The water trough for this purpose is a 0.45 m deep rectangular tank with a uniform 0.8 x 1.5 m^2 horizontal cross-section. Each lateral wall has a window made of acrylic glass. Through a hermetically sealed hole in the bottom of this tank passes into the tank the vertical output shaft of an electric drive mounted underneath the tank and consisting of a d.c. motor with a speed reducer. At the end of the shaft extension is mounted a wheel with a sheathed annular blade ring which generates a flow around the tank inside. On a bench along the tank is placed an LGN-406 Ar-laser, its beam being split and rotated by an optical system so that the inside of tank, including the wheel cavity, is uniformly illuminated from all four sides. Laser "knife edges" are formed by rotating mirrors and short-focus cylindrical lenses. As tracer particles are used, balls 0.5-0.7 mm in diameter made of transparent colorless polystyrene, the density of this material being close to that of water. The laser beam is mechanically chopped by means of a rotating disk, which facilitates detection of shorter tracks formed by particles crossing an illuminated plane obliquely and thus introducing errors in the estimation of their velocity. Chopping the laser beam causes the tracks of all particles to appear in the form of dashed lines, all lines in an illuminated plane having the same number of dashes when both the chopper disk and the photographic camera are held in certain respective positions. The apparatus was used for optimizing the circulation systems for two CO_2-lasers: a closed wind tunnel with a radial fan for the "Lantan" laser built at Institute of Mechanical Problems (USSR Academy of Sciences) and a closed cylindrical channel with a radial fan for the MLT-1.2 laser built at the Institute of Hydraulic Machines (Polish Academy of Sciences). Figures 3; references 9.

New Solid-State Passive Shutter for Neodymium Lasers

937J0011A Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 (manuscript received 6 Mar 92) pp 629-630

[Article by V. A. Zyulkov, A. E. Kazachenko, S. G. Kotov, D. V. Kovalev, and A. A. Stavrov, Byelorusian State Polytechnic Academy, Minsk, and Central Engineering Office "Peleng" (Bearing), Minsk; UDC 621.373.826.038.825.3]

[Abstract] A new type of passive shutter for Q-switching neodymium lasers has been developed, their material being a Na-Ca silicate glass doped with a $CuInS_{(1-x)}Se_{2x}$ semiconductor compound. Strong optical excitation of these glasses thus doped was found to induce a nonlinearity of their radiation absorption characteristic, a single 30 ps pulse of 1.064 μ radiation causing absorption of this radiation to saturate as its intensity reached 50 MW/cm^2 and to then resume increasing as its intensity reached 10 GW/cm^2. Experiments were performed with YAG:Nd^{3+} and $YAlO_3$:Nd^3 lasers. The active medium of each laser was together placed in a quantron together with an INP-5/75A flash lamp serving as the optical pump, a 1 m long optical cavity being formed by a spherical opaque mirror with a 2.5 m radius of curvature and a plane exit mirror with a 0.67 reflection coefficient. The lasers were tested in both monopulse and periodic-pulse-repetition modes, at 1-3 Hz pulse

repetition rates in the latter case. The emission threshold for the Q-switched YAG:Nd laser was 33-35 J. It emitted a train of 20-25 pulses having a 150-200 long envelope and carrying 0.1-0.3 J of energy at this pumping level, two or more pulse trains separated by 1-2 μs intervals at higher pumping levels. Figures 2.

Spectroscopic and Emission Characteristics of Ca-Nb-Ga Garnet Activated by Tm^{3+} and Cr^{3+} Ions

937J0011B Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 pp 631-633

[Article by Yu. K. Voronko, S. V. Gessen, N. A. Yeskov, A. A. Zverev, P. A. Ryabochkina, A. A. Sobol, S. N. Ushakov, and L. I. Tsymbal, Institute of General Physics at Russian Academy of Sciences, Moscow; UDC 621.373.826.038.825.2]

[Abstract] An experimental study of Ca-Nb-Ga:(Tm,Cr) garnet crystals was made concerning their radiation emission characteristics and luminescence spectrum. Single crystals of the Ca-Nb-Ga garnet were grown by the Czochralski method from a melt while being activated with Cr^{3+} ions and Tm^{3+} ions. The concentration of Cr ions was the same in all crystals: 4.10^{19} cm^{-3}. The concentration of Tm ions was varied: 1.27×10^{20} - 4.14×10^{20} - 8.24×10^{20} cm^{-3}. The luminescence spectrum of a Cr^{3+} ion is a wide bright line with maximum intensity at the 745 nm wavelength, corresponding to the $^4T_2 \rightarrow {}^4A_2$ transition, and quenching of its luminescence proceeds exponentially with a $\tau = 82$ μs time constant (radiative mean life of Cr ions). Not so in the presence of Tm ions, as recorded in Ca-Nb-Ga garnet crystals at the 752 nm wavelength at room temperature (300 K) upon their excitation with a 590 nm dye laser. The efficiency of energy transfer from Cr ions to Tm ions (energy = luminescence intensity J integrated with respect to time t; efficiency of energy transfer = 1 - ratio of energy emitted by Cr ions in presence of Tm ions to energy emitted by them in absence of Tm ions) has been estimated from the integral quenching characteristic, the latter indicating a static disordered quenching within the 0.5-55 μs time segment and a dipole-dipole interaction of Cr^{+3} - Tm^{3+} interaction. The integral quenching characteristic (total quenching time approximately 100 μs) has been plotted in three forms: 1) $\log[-\log J_{Cr,Tm} + t/\tau)]$ versus log t (ascending straight line), $\log J_{Cr,Tm} + t/\tau$ versus $t^{1/2}$ (descending straight line), $\log J_{Cr,Tm} + t/\tau$ versus t (first exponentially and then linearly descending curve). The experimental curves fit the theoretical ones closely throughout the 0.5-55 μs time segment, the difference between them in the final 55-100 μs time segment being attributable to intensified luminescence of Tm ions during their transition from the $^3H_4$ level. Two different Ca-Nb-Ga garnet crystals were tested for their laser characteristics at room temperature, crystal A containing 7 atom.% Cr + 0.5 atom.% Tm and crystal B containing 0.5 atom.% Cr + 6 atom.% Tm. They were pumped with pulses of 300 J energy and 2.7 ms duration at the 0.1 level, by an INP flash lamp in a KLZh luminaire. The optical cavity was formed by spherical dielectric mirrors with a 500 mm radius of curvature and a 1.0 reflection coefficient. The emission threshold was found to be 215 J for crystal A and 122 J for crystal B. Both crystals emitted 2.02 μm radiation, according to readings taken with an MDR-2 monochromator and PbS-photodetector. Figures 4; references 10.

Feasibility of and Conditions for Obtaining High Energy Characteristics of Pulsed Chemical HF-Laser by Using SF_6 + HI Mixture

937J0011C Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 pp 641-642

[Article by A. V. Gal, V. D. Rusanov, V. L. Shirayevskiy, and G. V. Sholin, Institute of Atomic Energy imeni I. V. Kurchatov, Moscow; UDC 621.373.826.038.823]

[Abstract] A pulsed chemical HF-laser with transverse electron-beam pumping has been developed for laser-induced thermonuclear fusion, higher energy characteristics having been obtained by using a SF_6 + HI rather than SF_6 + H_2 mixture. Inasmuch as the atomic number of iodine is higher than that of hydrogen, the much more intense scattering of electrons by iodine atoms lowers the pumping efficiency. This decrease of excitation efficiency has been compensated by an increase of the physical efficiency. The cell containing the active medium is a tube made of stainless tube with a 60 mm inside diameter and with 15 mm square leucosapphire windows slanted at the Brewster angle for radiation extraction. The laser was tested in 1.2 m long plane-parallel optical cavity between a plane copper mirror and a fluorite plate. A beam of electrons with a 220 keV average energy was generated by an accelerator in pulses of 40 ns duration at the 0.5 level. The accelerator consisted of a Marx generator of voltage pulses with a 12.5 nF impact capacitance, a double pulse-shaping line chargeable to 350 kV within 0.5 μs, and a high-voltage diode with sputter emission of electrons. The pulse shaper had a wave impedance of 7.8 Ω and a capacitance of 6.5 nF. It contained water as the dielectric material. The cathode was a metal plate with a 15 x 230 mm^2 large active surface. The anode was a 60 μm thick aluminum foil on an 80 percent optically transparent supporting grid of 2 mm thick metal wires, placed 14 mm away from the cathode serving as the anode. Scattering of electrons by the active medium along the path of the electron beam and their subsequent absorption by the cell walls were prevented was prevented by setting up a stationary uniform magnetic field of 2 kG intensity in the interelectrode space. The magnetic field raised the emission energy when the active medium operated under a low pressure, but did not prevent scattering of electrons by the active medium under high pressure and the attendant decrease of emission energy. The maximum specific emission energy attained without a magnetic field was 8 J/dm^3 per pulse and just as high with the magnetic field. Figures 2; references 13.

Passive Q-Switching of Nd^{3+}-Lasers With Phototropic Y-Sc-Ga:Cr^{4+} Garnet Shutters

937J0011D Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 pp 653-656

[Article by I. V. Klimov, M. Yu. Nikolskiy, V. B. Tsvetkov, and I. A. Shcherbakov, Institute of General Physics at Russian Academy of Sciences, Moscow; UDC 535.241.13:621.373.826]

[Abstract] Three garnet crystals were tested as lasers with Q-switching by a phototropic shutter for radiation emission in a sequence of high-power spikes. The Y-Al:Nd^{3+} crystal, with a brightener coating, was 6.3 mm in diameter and 7.0 mm long. The Y-Sc-Ga:(Cr^{3+}, Nd^{3+}) crystal, without a brightener coating, was 6.0 mm in diameter and 73 mm

long. The Gd-Sc-Al:Nd^{3+}(Cr^{3+}, Nd^{3+}) crystal, without a brightener coating, was 3.7 mm in diameter and 71 mm long. The shutter was a Y-Sc-Ga:Cr^{4+} crystal 9.3 mm in diameter and 61.5 mm long. The shutter crystal, with a 58 percent initial transparence for 1.06 μm radiation, was placed in a cavity in a special chamber behind the laser crystal and cooled after the latter with a 0.2 percent aqueous K_2CrO_4 solution. Each laser crystal was pumped by an INP 5/60 flash lamp. The exit mirror with a 0.18 reflection coefficient had been selected by the experimental method. The time characteristics of radiation emission by these laser crystals were recorded on S8-12 and S9-8 high-speed oscillographs, the characteristics of individual spikes being measured with an FEK-29KPU photocathode and the modulation frequency being measured with an LFD-2A avalanche photodiode. The emission power was measured with an IMO-2M instrument. The presence of Cr^{4+} ($3d^2$ ions in tetrahedral nodes in these rare-earth garnet crystals evidently contributed an additional absorption band within the 0.95-1.25 μm range. Emission of spike sequences was attainable whether the laser crystals were pumped continuously or in pulses. In the continuous pumping mode a small excess gain above initial losses did suffice for generating spike sequences with quite stable but rather low amplitudes and repetition rates, inasmuch as high pumping levels were not technically feasible. In the pulsed pumping mode it was technically possible to pump fast and attain a large excess gain over initial loss, the spike sequences thus having different characteristics. The modulation frequency in this case depended on the laser material, each having a different effective cross-section for the 1.06 μm radiative $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition: that of the Gd-Sc-Al:(Cr^{3+}, Nd^{3+}) being 0.9×10^{-19} cm^2, that of the Y-Sc-Ga:(Cr^{3+}, Nd^{3+}) being 1.5×10^{-19} cm^2, that of the Y-Al:Nd^{3+} garnet being 3.5×10^{-19} cm^2. The modulation frequency in the pulsed pumping mode was found to be unstable, most unstable in the case of the Y-Al:Nd^{3+} garnet with the largest transition cross-section. The advantages of these lasers are not only the possibility of growing large crystals with uniform radiation absorption over their entire volume, when properly cooled, but also their insensitivity to beam polarization and high photochemical stability. The authors thank Yu. D. Zavartsev and P. A. Studenikin for supplying the crystals. Figures 4; tables 1; references 15.

Numerical Analysis of Effect of Coma and Astigmatism Aberrations on Quality of Phase Conjugation by Stimulated Mandelshtam-Brillouin Scattering

937J0011E Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 pp 684-687

[Article by Yu. F. Kirvanov, G. G. Kochemasov, N. V. Maslov, and I. V. Shestakova, All-Russian Scientific Research Institute of Experimental Physics, Arasmas-16 (Nizhegorod Oblast); UDC 621.373.826]

[Abstract] Phase conjugation of single-mode Gaussian light beams with wavefront aberrations by stimulated Mandelshtam-Brillouin (M-B) scattering is considered, of particular concern being aberrations which break the axial symmetry: coma and astigmatism. The problem is a three-dimensional one, formulated here in the approximation of a linear pump, which corresponds to a small reflection coefficient within the 0.01-0.1 range. The general system of two three-dimensional second-degree differential equations describing phase conjugation by steady stimulated MB scattering is solved for a linearly polarized light beam in the approximation of a given pump. This is done by a transformation of coordinates in such a way that the light beam to be focused by a lens appears to have a plane wavefront in the ideal aberration-free case, with the aberrations then introduced in the form of additional phase multipliers in the expression for the boundary value of the pump field. The initial pump intensity distribution is assumed to simulate an apodized shelf. Numerical calculations have been made for a 1 m long active medium facing a lens with a 1 m focal length at a distance of 50 cm. First was solved the diffraction problem of pump radiation transfer to the far end of the active medium 150 cm away from the lens, Stokes noise radiation at this point representing a superposition of 10 x 10 different Hermitian-Gaussian modes along the transverse coordinates with random phase distribution. The thus calculated intensities of interacting fields at this point were then used as boundary conditions for solving the next problem of concurrent stimulated M-B scattering. An analysis of the results indicates that coma significantly decreases the wavefront reversal fidelity while astigmatism has no appreciable effect on it. The results also indicate that as either of the two aberrations increases, the stimulated M-B scattering threshold will rise in an almost linear relation. Figures 5; references 9.

Dynamics of Emission Self-Starting in Semilinear Phase Conjugating Mirror With Many Transverse Modes

937J0011F Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 19 No 7, Jul 92 pp 691-697

[Article by N. I. Beldyugina, A. V. Mamayev, and V. V. Shkunov, Institute of Problems in Mechanics at Russian Academy of Sciences, Moscow; UDC 621.373.826]

[Abstract] Self-starting of radiation emission in a semilinear phase conjugating mirror with a photorefractive crystal as the nonlinear medium is considered, the dynamics of this process being analyzed for the general case of many transverse modes in the optical cavity formed by this crystal and a plane or spherical mirror. The analysis is based on the system of four differential equations which, according to the plane wave model, describes interaction of the fields of four electromagnetic waves and a grating which transmits them without attendant linear absorption. On this basis is obtained an S-form dependence of the steady-state reflection coefficient on the nonlinearity parameter (coupling constant). The emission threshold is then determined on the basis of the more adequate double reversal model. With the problem subsequently reformulated for a multimode phase conjugating cavity, the emission threshold is determined in the Born approximation and the length of time of the preceding "silence period" is calculated accordingly. Emission in the coupled waves mode is considered next and the

results of its theoretical analysis are compared with experimental data on self-starting. Experiments were performed with a He-Cd laser emitting 0.44 μm radiation with a power of about 40 mW, a semitransparent mirror splitting the beam into a pump beam and a priming signal beam. The nonlinear optical cavity was formed by an about 9.5 mm thick photorefractive crystal and plane mirror with an about 0.85 reflection coefficient. Inside this cavity were placed a lens with an about 35 mm focal length and an iris, a half-wave plate and a polarizer in the path of the signal beam. The priming wave was, prior to its entry into the cavity, passed through a phase plate which induced in it a speckle structure simulating the Penning speckle structure and so could be used for monitoring the quality of phase conjugation inside the cavity. Following these experiments, a specially shaped second priming wave was injected into the cavity and the iris aperture was set at about 5 mm so as to prevent self-starting of radiation emission by linear noise in the crystal. The results indicate that excitation of a non-linear phase conjugating cavity with many transverse modes proceeds in two stages. In the first stage restructurization of the grating profile gives rise to a mode which ensures coupling of counterpropagating waves, but only when a certain threshold depending on the intensity of the priming radiation is exceeded. No phase conjugation of the pumping reference wave takes place in this stage. In the second stage is characterized by a steep increase of both the emission intensity and the reflection coefficient for the reversed wave now facing the pump wave. Figures 8; references 12.

High-Frequency Modulation of n+/AlGaAs/GaAs/p+/AlGaAs-Laser Output Power by Heating Electric Field

937J0023A St.Peterburg FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 26 No 3, Mar 92 pp 401-407

[Article by V. B. Gorfinkel and I. I. Filatov, Institute of Radio Engineering and Electronic at Russian Academy of Sciences, Saratov; UDC 621.315.592]

[Abstract] The performance of an n+/AlGaAs/GaAs/p+/AlGaAs double-heterostructure semiconductor laser in a high-frequency electric field or upon application of a picosecond voltage pulse is analyzed, taking into account the attendant heating effect. The mathematical model which describes the resulting modulation of the laser emission power includes three laser equations: 1) two equations for the rates of change of electron concentration $dn_{\Gamma,L}$ in the Γ valley (narrow-gap layer) and in the L-valley (wide-gap layer) respectively, each generally involving the two $W_{\Gamma,L,L,\Gamma}$ speeds of both Γ → L and L → Γ intervalley transitions; 2) one equation for the rate of change of photon concentration. The total electron concentration is $n = n_\Gamma + n_L = p$ and the total pump current is $I = I_\Gamma + I_L$. The mobility of holes is assumed to be so low that their temperature can be regarded as being the same as the lattice temperature. The light amplification factor is proportional to the probability of electron transition from the valence band to the conduction band and the electron temperatures of electrons in the two valleys in the active region are determined from the equations of electron energy balance. The rate of change of electron temperature T_Γ in the Γ-valley is calculated by integrating the rate of electron scattering in this valley by polar optical phonons with a Fermi distribution function and the energy lost by hot electrons may then be determined on this basis, inasmuch as calculations made by the Monte Carlo method have revealed that in electric fields of $E < 2$ kV/cm intensity the electron distribution function at temperature $T = 300$ K does not appreciably differ from the Fermi distribution function. Inasmuch as even relatively weak heating electric fields of $E \leq 2$ kV/cm intensity are capable of modulating the light amplification factor, the system of laser equations is simplified by disregarding both intervalley transition and expulsion of thermalized electrons from the narrow-gap semiconductor layer. An analytical solution of this system of equations is facilitated by assuming that the electron mobility and the energy relaxation time in the Γ-valley remain constant. Numerical calculations were made for an n+/$Al_{0.33}Ga_{0.67}As$/GaAs/p+/$Al_{0.33}Ga_{0.67}As$ laser heterostructure ($W = 300$ μm, $L = 3$ μm, $d = 0.2$ μm; optical limitation factor $G = 0.3$, spontaneous emission coefficient $\beta = 0.001$) with a known power-current characteristic, for a quantitative comparative evaluation of emission power modulation by: 1) a small current with an alternating component $I(t) = I_0 + I$; 2) a weak electric field with a sinusoidally alternating component $E(t) = E_0 + E$, in which case that modulation depends on the E/E_0 ratio; 3) a strong sinusoidally alternating electric field $E(t) = E$; 4) "forward" and "backward" ultrashort rectangular E_0 pulses. Thus have been obtained the following emission characteristics: 1) dependence of the emission power on the frequency, up to 100 GHz, of the alternating current component in a constant electric field and on the frequency of the alternating electric field component at a constant current; 2) time response of the emission power and of the Γ-valley electron temperature to a sinsoidally alternating field with and without constant component; 3) frequency dependence of the maximum emission power and the power modulation factor; 4) frequency spectra of the emission power modulated by an electric field $E = E_0 + E_1\sin 2\pi f_1 t + E_2\sin 2\pi f_2 t$; 5) responses of the emission power and the Γ-valley electron temperature to rectangular $E_0 = 1$ kV/cm "forward" and $E_0 = 1.5$ kV/cm "backward" pulses of 20 ps or 5 ps duration. Figures 6; references 2.

Devices for Focusing of Near-Infrared Laser Radiation

937J0025A St.Peterburg PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 18 No 15, 12 Aug 92 pp 39-41

[Article by M. A. Golub, L. L. Doskolovich, N. L. Kazanskiy, I. V. Klimov, V. A. Soyfer, G. V. Uspleniyev, V. B. Tsvetkov, and I. A. Shcherbakov]

[Abstract] Devices for shaping and focusing beams of 1.06 μm Nd-laser radiation and also adaptable for 10.6 μm CO_2 radiation in the kilowatt range have been developed by the Central Design Office for Unique Devices, Samara branch, at the Russian Academy of Sciences. The three devices feature a stepped microrelief profile and focus a shaped laser beam onto a dot, a segment, or a ring respectively. Difficulties associated with the low maximum resolution (50 lines/mm) attainable with plotting phototemplates and the large minimum width, up to 2.5 μm, of the focusing zone $\delta = f\lambda/dM$ = (f - focal length, μm - wavelength, d - dimension of focusing device, M - number of phase quantization levels)

have been overcome by application of various microlithographic fabrication methods such as electron lithography and photoreducing projection lithography. The devices were tested at the Institute of Optical Physical Measurements (Russian Academy of Sciences) with a Y-Sc-Ga:(Cr,Nd) garnet laser operating in the pulsed free emission mode, emitting pulses of 800 μs duration and 8 J energy at a repetition rate of 10 Hz. The focusing devices had reduced the beam divergence to 0.25° max. Figures 2; references 7.

Mechanism of Emission Power Boosting in Gas-Discharge CO_2-Laser With Distributed Catalyst

937J0025B St.Peterburg PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, Vol 18 No 15, 12 Aug 92 pp 93-96

[Article by G. I. Kozlov, A. V. Kachalin, V. A. Kuznetsov, and O. G. Sidorenko, Institute of Problems in Mechanics at Russian Academy of Sciences]

[Abstract] Boosting the emission power of a gas-discharge CO_2-laser by means of a catalyst is considered as a way to overcome the decrease of its emission power due to the decreasing concentration of CO_2 molecules and to the deactivation of vibrationally excited CO_2 molecules in the active medium by atomic oxygen, ozone, and nitrogen oxides. Regeneration of CO_2 molecules immediately inside the gas-discharge tube by deposition of a catalyst such as a gold film on its inside surface having already been successfully tried (J. A. Macken, S. K. Yagnik, M. A. Samis; IEEE Journal of Quantum Electronics, Vol 25 No 7, 1989), an experimental study was made for the purpose of determining the effect of such a catalyst on the performance of the laser inside a waveguide-cavity and for an explanation of the power boosting mechanism. The experiment was performed with two gas-discharge glass tubes inside a common optical cavity, one with a gold coating and one bare. Both tubes had a 180 cm active length and a 10 mm inside diameter. Both tubes were cooled. The cavity was formed by two plane mirrors: a water-cooled opaque copper mirror and a 0.43-reflectance GaAs exit mirror. The active medium pumped through each tube was a CO_2:N_2:He = 10:20:70 mixture. The emission power was measured with a calorimeter and the degree of CO_2 dissociation was measured with the aid of a chromatograph, the two laser being tested separately. When both lasers operated with an input power density of 300 W/m, the catalyst was found to increase the emission power by about 25 percent by having increased the concentration of CO_2 molecules and decreased the concentration of oxygen atoms. Surprisingly, the emission of the laser with a catalyst even continued to increase with increasing input power, up to a level almost 1.5 times higher than the maximum emission power of the laser without a catalyst, without overheating of the active mixture. A possible explanation is that deposition of the catalyst coating automatically triggers a diffusion-recombination mechanism of heat transfer from along with transfer of CO molecules and O atoms from the paraxial region of the discharge tube to its wall. There they recombine on the catalyst coating and release most of the dissociation energy to it, thus facilitating further heat transfer from the paraxial region. Figures 2, references 3.

Study of Dynamics of Photoprocesses in Organic Compounds for Creation of New Active Media and Dye Lasers

937J0035A Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian No 9, Sep 92 pp 77-85

[Article by G. V. Mayer, V. Ya. Artyukhov, T. N. Kopylova, I. V. Sokolova, and O. K. Bazyl, Siberian Institute of Engineering Physics imeni V. D. Kuznetsov at Tomsk State University; UDC 539.194:621.373]

[Abstract] A method of predicting the luminescence spectrum and other emission characteristics of organic dye molecules as potentially effective active laser media has been developed, it being necessary for this to determine: 1) how their relevant physical and chemical properties are related to their structural characteristics, 2) how the intramolecular interactions depend on the characteristics of the pumping electromagnetic field. The first part of the problem has been reduced to one of determining how the mechanisms of intramolecular photophysical and photochemical relaxation processes depend on the molecular structure of such organic compounds. The rate constants of these relaxation processes are estimated on the basis of the modern nonradiative conversion theory, considering that absorption of a photon by a molecule is followed not only by radiative decay in the form of luminescence but also by nonradiative internal singlet-to-singlet or triplet-to-triplet conversion and intercombinational singlet-to-triplet or triplet-to-singlet conversion along with photochemical reactions and light absorption in electronic excitation states. A program package has been written for systematic calculations leading to construction of schematic diagrams of electronic excitation states in these molecules and to a classification of π-electron molecules according to their luminescence spectra, also pertaining to mechansisms of the photophysical processes in organic (aromatic, heterocyclic) compounds, as the basis for estimating their light emission activity. Several molecular structures capable of lasing have already been predicted and subsequently synthesized. New optically stable active media were for dye lasers with excimer-laser pumping were explored by this method, among them several compounds for blue and green lasers with pumping by a XeCl-laser such as the Lida-101. These are: 0.008 mol./l ethanol solutions of coumarin-102 (475 nm), MK-4871 (480 nm) AC3F (497 nm), T-698 (497 nm), alone or with 0.05 mol./l diazobicyclo-octane (DABCO). Use of various organic or inorganic sorbents was found to appreciably increase the lasing efficiency of such organic dye media to about 30 percent, addition of DABCO to increase their efficiency only slightly but their specific energy capacity in J/cm^3 by a factor of 4-10. A noteworthy development based on these studies is the MZhL-03 pulsed dye laser (tuning range 330-800 nm, width of emission line 0.01-15 nm, beam divergence 1-2 mrad, pulse duration 50-100 ns, pulse energy 150 J, capability 10^7 - 10^8 pulses) for an environmental in-depth sounding DPR-lidar used in measurement of NO_2 concentrations or in other test procedures. Figures 2; tables 2; references 2.

Characteristics of Phased Injection-Laser Arrays in Fresnel Region

937J0036A Minsk DOKLADY AKADEMII NAUK BYELARUSI in Russian Vol 36 Nos 9-10, Sep-Oct 92 pp 806-809

[Article by Ya. V. Alishev, O. A. Khatskevich, and V. Ye. Yamaykin, Minsk Institute of Radio Engineering; UDC 621.373.826.038.825.4]

[Abstract] Radiation patterns of two-dimensional injection-laser arrays in the Fresnel region are analyzed numerically, for a determination of their dependence on the beam focusing and on the width of their emission spectrum. A square array of 10x10 elements is selected as the basic configuration, each element being a rectangular (one wavelength wide in the E-plane and five wavelengths wide in the H-plane) single-mode radiator of linearly polarized light. Both radiation patterns, in the E-plane and in the H-plane respectively, are calculated for the following variants of this array: 1) unphased array of noncoherent radiators; 2) unphased array with a lens focusing the light onto a spot at a finite distance (entrance to fiber-optic transmission line); 3) cophasal monochromatic laser array; 4) cophasal laser array with such a focusing lens; 5) laser array phased for maximum light intensity at a finite distance (entrance to fiber-optic transmission line); 3,4,5 with finite spectral width. The dependence of the radiation pattern on the width of the laser emission line is evaluated on the basis of a comparative data analysis. Calculations for narrow-spectrum arrays (relative width of emission spectrum $\Delta\lambda/\lambda_0 < 0.01$; λ_0 - center wavelength, $\Delta\lambda$ - width of emission line) are made in the monochromatic approximation and calculations for arrays with wider spectra are based on the light intensity at the center of the focal spot, its intensity there being estimated as that of light arriving in wave trains of finite length approximately equal to the center wavelength divided by the relative width of the emission spectrum. Figures 2; references 7.

Measuring Loss Coefficient of Ultracold Neutrons in Beryllium Powder

927J0247A Moscow YADERNAYA FIZIKA in Russian Vol 55 No 3, Mar 92 pp 608-616

[Article by V. V. Golikov, V. K. Ignatovich and Ye. N. Kulagin, Joint Nuclear Research Institute, Dubna]

[Abstract] The reflection of ultracold neutrons from beryllium powder was measured in different layer thicknesses and with different packing densities. Measurement of the loss coefficient by the powder reflection method proposed earlier by the authors is superior to the method of storage in a closed trap, making possible more careful monitoring of sample thermal processing. The method was used earlier in measuring loss coefficients in copper, cupric oxide, graphite and beryllium, but some doubts prevailed concerning validity of the results, dictating further research along these lines. Section 2 describes the theory of diffusion of ultracold neutrons in powder; Section 3 describes the measurement method; Section 4 summarizes and discusses the measurement results. An experiment is described in which the reduced loss coefficient v with reflection from nonthermally treated beryllium was retrieved experimentally: $v = (1.75 +/- 0.35) \times 10^{-4}$. Experimental data on the reflection of ultracold neutrons from beryllium powder after high-temperature heating are reexamined. The v value determined at room temperature is $(6.4 +/- 2.5) \times 10^{-5}$, which exceeds the theoretical value by an order of magnitude. The measurements were processed using a modified diffusion theory in which albedo is dependent on packing density. Figures 3; references 16: 14 Russian, 2 Western.

Internal Parity of Antiparticles

927J0247B Moscow YADERNAYA FIZIKA in Russian Vol 55 No 3, Mar 92 pp 707-715

[Article by Z. K. Silagadze, Nuclear Physics Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] The principal objective of this study is resurrection of one of the old ideas of L. Michel (NUCL. PHYS., Vol 57, p 356, 1964): the mathematical technique of extension of groups may be useful in an examination of physical problems. Accordingly, the author considers the applicability of extension of groups to such concepts as the charge conjugation operator in calibration theories or discrete symmetries and possible generalizations for the case of supersymmetry. The relevance of relativistic invariance and related concepts also is evaluated. These ideas were invoked in examining the quantum-mechanical parity operator in the case of free fields without drawing on the extension of groups approach in its full scope. It is shown that an ordinary situation when the internal parities of a particle and antiparticle are identical for bosons and opposite for fermions in some sense assumes a local character of the theory. In a more general case when the quantum-mechanical parity operator is determined using the mathematical technique of extension of groups an anomalous parity operator also arises for which the internal parities of a particle and an antiparticle are identical for fermions and opposite for bosons. References 15: 4 Russian, 11 Western.

Influence of Hybridization of Electron States of Uranium Shell With Immersion in Silver on Conversion Probability of Isomer ^{235m}U

927J0248A Moscow YADERNAYA FIZIKA in Russian Vol 55 No 2, Feb 92 pp 304-309

[Article by M. M. Vsevolodov, V. Yu. Dobretsov and D. P. Grechukhin, Atomic Energy Institute imeni I. V. Kurchatov]

[Abstract] The isomer ^{235m}U is actively used in research on the electron structure of condensed substances containing uranium. Recently published experimental data (V. V. Koltsov, et al., IZV. AN SSSR: SER. FIZ., Vol 53, p 2085, 1989) gave the half-life for this isomer when positioned deep within a silver layer. However, new data have been obtained contradicting the findings published there. A study was made of the possible nature and scale of the influence of hybridization of orbital electrons of a uranium atom immersed in silver on the decay rate of the nuclear isomer ^{235m}U. The various mechanisms possibly responsible for change in the conversion factor are examined. The influence of restructuring of the electron shell of this atom on the conversion rate was investigated in detail and the computation model employed is fully described. The computations were made in a cluster model in the muffin-tin approximation. When ^{235m}U is surrounded by silver there is an increase in the conversion rate (about 10 percent). It is concluded that the hybridization effects in this case cannot lead to slowing of ^{235m}U conversion by several times, as found by V. V. Koltsov, et al., but instead an acceleration occurs. The half-life given in that study also is incorrect. Figure 1; references 11: 8 Russian, 3 Western.

Transit of Particles Through Multilayer Tunnel Structures

927J0258A St. Petersburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 1, Jan 92 pp 92-97

[Article by O. Z. Olendskiy, Belorussian State University imeni V. I. Lenin, Minsk]

[Abstract] It is shown that for a particle tunneling through a system of two potential barriers to which a voltage U is imparted and for which the heights change harmonically with time with the frequency ω the coefficient of transit, without emission or absorption of a quantum of oscillations, has a resonance dependence on U. Oscillations of the heights of the barriers leads to the appearance of several channels equidistant in energy corresponding to absorption or loss of energy by a particle. With an increase in the modulation frequency ω the resonance value of the transit coefficient decreases but the resonance curve is displaced into the region of lesser voltages. For transit with particle emission or absorption of a quantum of oscillations the transit coefficients also have a resonance dependence on voltage. Resonances are observed for transit with absorption with $U_<$ and U_{max} and for transit with emission with U_{max} and $U_>$, where $U_< < U_{max} < U_>$ and U_{max} is the voltage at which the maximum of the transit coefficient without emission or absorption is attained; $U_>$ is situated closer to U_{max} than $U_<$; this asymmetry increases with an increase in ω. Ways to increase the efficiency of interaction of a tunnelling particle with oscillations are defined. Figures 4; references 6: 5 Russian, 1 Western.

Thermal Effect of Pulsed Microwave Radiation on Structurally Inhomogeneous Materials

927J0258C St. Petersburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 1, Jan 92 pp 42-54

[Article by Ye. A. Galstyan and A. A. Ravayev, Moscow Radio Engineering Institute, Russian Academy of Sciences]

[Abstract] A study was made of the behavioral responses to a pulsed exposure of composition (disperse) materials to the thermal impact of high-frequency electromagnetic energy. The materials considered constituted a dielectric matrix in which foreign absorbing particles are admixed. The approach employed in solving the pertinent nonstationary thermal problem is quite similar to that used by R. W. Hopper, et al. (J. APPL. PHYS., Vol 41, No 10, pp 4023-4037, 1970). It is applied in solving the nonstationary problem of pulsed microwave heating of dielectrics containing absorbing inclusions for cases of an arbitrary volumetric concentration. Formulas are proposed for the effective absorption section of the inclusions and analytic expressions are written for computing the temperature fields in the volume of such materials. The temperature stability of the characteristics of radioabsorbing materials and artificial dielectrics is examined. In a general case the microwave heating of these composition materials has a nonlinear character and the corresponding problem requires allowance for the dependence of all the physical constants of both the particles of the filler and the matrix on temperature. Solution of the problem in analytic form is impossible. For numerical computations it is possible to use the results published in a number of studies where formulas are given for computing the effective electrodynamic parameters of disperse media with two-layer spherical inclusions. Figures 4; references 25: 19 Russian, 6 Western.

Spectra of Secondary-Neutron Emission During Bombardment of U-235 Nuclei by 5.9 MeV Neutrons

927J0273A Moscow YADERNAYA FIZIKA in Russian Vol 55 No 7, Jul 92 pp 1754-1758

[Article by G. N. Lovchikova, A. V. Polyakov, S. E. Sukhikh, and A. M. Trufanov, Institute of Physics and Energetics, Obninsk]

[Abstract] Spectra of neutrons emitted from ^{235}U nuclei during bombardment of these nuclei by 5.9 +/- 0.06 MeV neutrons were measured, following earlier measurements made when these nuclei were bombarded by 4.9 MeV neutrons. Measurements were made by the time-of-flight method. The source of monoenergetic neutrons was a gaseous tritium target bombarded by a proton beam from a pulsed EGP-10M overcharge particle accelerator. The specimen of metallic uranium was a hollow cylinder 50 mm long with a 45 mm outside diameter and a 2.5 mm wall thickness, located at a distance of 168 mm away from the center of the tritium neutron source and oriented parallel to the proton beam. It was placed inside a cadmium jacket so as to minimize fission of ^{235}U nuclei by slowed-down (thermal) incident neutrons. Neutrons leaving this scatterer-target were recorded by a detector at a distance of 198 cm away from it, the detector containing a stilbene crystal 3.9 cm long and 6.3 cm in diameter and feeding signals to an FEU-30 photomultiplier. The detector was placed inside a bulky protective Fe-Pb-LiH-paraffin-polyethylene shield. Background noise caused by emission of γ-quanta was suppressed by separating them from neutrons, the waveform of the electric signal serving as the reference in this scheme. The incident primary neutron flux was monitored by a scintillation detector, with which were also measured the time spectra of neutrons leaving the target in 480 channels. The neutron flux leaving the target was also monitored by an all-wave counter. Protons falling into the uranium target were monitored by a charge (number) of protons integrator. Neutron emission from the uranium target was measured at 45°, 60°, 90°, 120°, 150° angles from the incident neutron beam. The procedure was to measure the spectrum of neutrons leaving the uranium target in each direction together with the background noise caused by incidence of low-energy (thermal) primary neutrons and to measure the background noise separately without the uranium target inside the cadmium jacket. These measurements were repeated without tritium in the neutron source, for monitoring the emission of fission neutrons. The statistical error of measurements was within 3-4.5 percent in the energy range up to 5 MeV and within 5-20 percent in the energy range above 5 MeV. The efficiency of the neutron detector was determined in an experiment with prompt ^{252}Cf-fission neutrons. With the background noise subtracted and with the number of emission neutrons normalized to the number of incident primary neutrons, the time spectra of neutron emission by the uranium target have been converted into energy spectra neutrons leaving the target, spectra of double differential with respect to energy and angle cross-sections for emission. From these spectra have then been subtracted the spectra of fission neutrons, leaving those of elastically scattered and inelastically scattered ones. The thus corrected energy spectra indicate that 0.6-4 Mev secondary neutrons are emitted by an evaporation mechanism. Emission of secondary neutrons with higher than 4 MeV energy is difficult to interpret, because in this range the spectra represent the sum of elastically and inelastically scattered neutrons. Figures 5; references 4.

Possibility of Exploring Dimensions of Region of Fast-Protons Production

927J0273B Moscow YADERNAYA FIZIKA in Russian Vol 55 No 7, Jul 92 pp 1854-1860

[Article by N. A. Kalinina, Scientific Research Institute of Nuclear Physics (branch) at Moscow State University), R. Lednitskiy and D. M. Khazins, Joint Institute of Nuclear Research, Dubna]

[Abstract] Production of fast protons is considered and the dependence of their correlation functions on the dimensions of the region where they are produced is shown to be helpful in exploring the dimensions of this region. These correlation functions are calculated for proton pairs, taking into account two-particle interaction in the final state. The value of the two-particle correlation function is, according to definition, $b(p_1,p_2) = W(p_1,p_2) - 1$ and $W_{1,2}$ is the probability of 4-momentum p_1,p_2 particles being produced at points $x_1(r_1,t_1),x_2(r_2,t_2)$ (r - radius, t - time). For a region with spherical symmetry the two-particle correlation function averaged over the distribution of particle emission points in space and time depends on the three variables q_i,

q_0, v only (v - velocity of proton pair, $q_1 + q_2 = q$, q_t - transverse component of q, q_l - longitudinal component of q, $q_0 = q_l v$). The distribution of recordable proton pairs was simulated, assuming each proton of a pair to have been produced independently and thus ignoring the correlation established by the dynamics of proton pair production in the calculation of its probability. For the simulation was, moreover, used the invariant inclusive cross-section for one-proton production in its analytical form (K. Guettler et al.; PHYSICS LETTERS Vol B64, 1977). On the basis of this simulation has been demonstrated the possibility of exploring the dimensions of the region where fast protons are generated in the "Positronium" facility with a carbon target by secondary emission with momentum $p_{1,2}$ up to 2.5 GeV/s and recordable within a solid angle of 35 μsr only, the r.m.s. radius of a proton production region anywhere known to be smaller than the r.m.s. nuclear radius of the the target element. Figures 5; references 11

Quantum-Theoretical Calculation of Rates of Mesohydrogen Recharge on Helium Targets by Direct Radiation and by Direct Conversion Mechanisms

937J0002A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 102 No 3, Mar 92 pp 755-759

[Article by A. V. Kvartsov and A. I. Mikhaylov, Peterburg Institute of Nuclear Physics imeni B. P. Konstantinov at Russian Academy of Sciences]

[Abstract] Two mechanisms of muon transfer from mesohydrogen to helium are considered: direct radiation mechanism $(p\mu)_s + H^{++} \rightarrow (He^{++}\mu)_{1s} p + \gamma$ and direct conversion (Auger) mechanism $(p\mu)_{1s} + He^{+} \rightarrow (He^{++}\mu)_{1s} + p + e$. Emission of a photon or an electron introduces an additional smallness into the recharge process, owing to weakness of electromagnetic interactions. Both reactions are nevertheless competitive with the $(p\mu)_{1s} + He^{++} \rightarrow (He^{++}\mu_{1s} + p$ reaction (A. V. Matveyenko, L. I. Ponomarenko; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 63 No 1, 1972), owing to the large amount of energy released during the muon transfer and carried off by the photon or electron with a resulting adiabatic scatter of nuclei. Most significant in these two reactions is the dipole transition between terms $2p\sigma$ and $1s\sigma$ from the S-wave state to the P-wave state of the relative motion of nuclei, only slow collision being considered in the quantum-theoretical calculation of the recharge rates in the six $(p,d,t)\mu + (^3He,^4He)$ systems at temperatures covering the 20-1000 K range. These rates, averaged over a Maxwell distribution, are found to be of the 10^6 s^{-1} order of magnitude in recharge by the radiation mechanism and of the 10^5 s^{-1} order of magnitude in recharge by the conversion (Auger) mechanism. The spectra of conversion electrons are similar to the photon emission spectra, none of them depending on the collision energy in the low-energy range. The authors thank V. Chaplinskiy for helpful discussions. Figures 3; tables 2; references 10.

Radiation Emission by System of Fast Charged Particles in Dispersive Scattering Medium

937J0002 Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 102 No 3, Mar 92 pp 791-803

[Article by A. V. Koshelkin, Moscow Institute of Engineering Physics]

[Abstract] Radiation emission by a system of fast noninteracting charged particles upon their multiple inelastic scattering by randomly located atoms of a dielectric dispersive medium is analyzed, assuming an arbitrary dispersion law $k(\omega) = \varepsilon^{1/2}(\omega)\omega$ (ω - radiation frequency, k - arbitrary wave vector, ε - dielectric permittivity). A beam of particles classical with respect to velocity (energy $E >> \omega$) and ultrarelativistic with respect to mass (energy $E >> m$) is considered which has entered a homogeneous amorphous dielectric medium occupying a half-space. The frequency spectrum of its radiation emission energy is calculated, with both Planck's constant and the speed of light reduced to unity. At time $t = 0$ the velocities of particles at random points N in the medium each have a magnitude $v_0 = [1 - (m/E)^2]^{1/2}$ and a direction only slightly deviating from the direction of the vector inward normal to the boundary of the medium. The far long-wave ($\omega \rightarrow 0$) radiation in a medium with a still finite frequency-dependent permittivity is mostly bremsstrahlung emitted under conditions of complete coherence with the slope of the spectrum proportional to the number of particles squared, emission of Cerenkov-Vavilov radiation when $\beta < 0$ being strongly suppressed. The ultrahigh-frequency radiation is mostly Cerenkov-Vavilov radiation when $\beta < 0$ or Bethe-Heitler radiation when $\beta > 0$, bremsstrahlung being strongly suppressed and the slope of the spectrum being proportional to the number of particles. A unidirectional δ-pulse beam of ultrarelativistic charged particles is considered as a special case and the frequency spectrum of its radiation emission energy is calculated next, of particular interest then being the bremsstrahlung emitted by such particles moving in a Maxwell plasma and Cerenkov-Vavilov radiation emitted by such particles moving in an atomic medium. Figures 3; references 12.

Symmetric and Asymmetric Fission of U-238 and U-235 Nuclei by Tagged Medium-Energy Photons

937J0026A Moscow YADERNAYA FIZIKA in Russian Vol 55 No 10, Oct 92 pp 2623-2633

[Article by D. I. Ivanov, V. G. Nedorezov, and A. S. Sudov, Institute of Nuclear Research at Russian Academy of Sciences, G. Ya Kezerashvili, Institute of Nuclear Physics at Russian Academy of Sciences, Siberian Department, Novosibirsk, A. A. Turinge, Kurchatov Institute, Moscow]

[Abstract] An experimental study of fission of U-238 and U-235 nuclei by 60-240 Mev photons was made in the ROKK-2 facility (Institute of Nuclear Physics, Novosibirsk), using the VEPP-3 electron storage ring and back-scattered Compton photons. A tagging system with a 5 MeV resolution extracted such photons from a bremsstrahlung beam of about 10^6 γ/s intensity and 2 GeV maximum energy. The experiment was performed with specimens of U-238 targets and U-235 targets, four of each, about 0.1 mg/cm^2 thick and 42 mm in diameter on 70 mg/cm^2 Al_2O_3 substrates. Each was placed facing the normally incident photon beam in the cavity of a separate fragment detector, each of them subtending a solid angle of $1.3/2\pi$ sr and containing isobutane under a pressure of 0.1 atm. The four detector with targets of one kind were then placed between proportional chambers with a 72 x 80 mm^2 large sensitive surface area each, in such a way as to make

the target-to-anode distance 35 mm long and the cathode-to-cathode distance 10 mm long. A Cf-252 source of spontaneous-fission fragments covering a complete solid angle was used as a reference. Analysis of the readings and theoretical calculations based on the Gangrskiy-Markov-Perelygin equation for the energy gradient dE/dx and yielding the loss of energy per unit distance traveled (Yu. P. Gangrskiy, B. N. Markov, V. P. Perelygin; 1981) reveal the mass distributions of moderated heavy fragments with up to about 20 MeV energy and of not moderated light fragments with energy from about 100 MeV up in the experiment. They also yield probabilistic estimates of both symmetric and asymmetric fission components. Further calculations based on the model of intranuclear cascade evaporation indicate an 80 MeV mean excitation energy during subsequent photon bombardment of the two nuclei when statistical equilibrium has been reached, this excitation energy only slightly depending on the incident photon beam energy. The ratio of asymmetric to symmetric fission was found to be only 0.32 +/- 0.2 for U-238 and 0.20 +/- 0.1 for U-235. Shell effects leading to asymmetric fission of nuclei must in this case be very weak at such a high level of excitation energy, as has already been noted before. Figures 6, tables 1; references 14

Nonlinear Dynamics of Multimode Dye Laser With Variable Dispersion in Optical Cavity and Sensitivity of Intracavity Laser Spectroscopy

937J0010A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 55 No 10, 10-25 May 92 pp 559-562

[Article by S. Ye. Vinogradov, A. A. Kachanov, S. A. Kovalkenko, and E. A. Sviridenkov, Institute of Physics imeni P. N. Lebedev at Russian Academy of Sciences, Moscow]

[Abstract] Multimode lasers with a uniformly widening amplification line are considered for intracavity laser spectroscopy of various kinds of motion and for generation of picosecond or femtosecond light pulses. Such lasers are an excellent model of multidimensional dynamic systems with stiff integral parameters: total emission power, spectral width, and gain being those which characterize the laser performance. The four factors determining the dynamics of radiation emission in each mode are total gain and losses in it, quantum noise, and nonlinear interaction of modes. The equation of field amplitude kinetics in any one mode has accordingly four additive terms on the right-hand side, where losses include not only intracavity absorption losses in that mode but also losses dissipated at the same rate in all modes and where the gain in the active medium appears with a coefficient which accounts for absorption saturation. While nonlinear interaction of modes is constant, the quantum nature of radiation emission gives rise to a random force which is a function of time. An analysis of the nonlinear emission dynamics aided by a numerical solution of that equation, the results of which agree closely with experimental data, demonstrates the feasibility of stabilizing the emission in each mode and thus increasing the sensitivity of laser spectroscopy by suppressing the nonlinear interaction of modes and the also nonlinear Mandelshtam-Brillouin scattering. This scattering was effectively suppressed by construction of a unidirectional traveling-wave ring laser and placing it in an optical cavity formed by two spherical mirrors and two plane mirrors, the back surfaces of the plane ones being beveled at a 10° angle for elimination of strobing effects. Unidirectional emission was ensured by means of a nonreciprocal device made of MOS-13 glass with Brewster facets in the gap of a permanent magnet generating a field about 1 kG strong along its axis. Dynamic chaos in each mode was thus converted into slow regular self-excited oscillations of the radiation intensity, most likely resulting from parametric interaction of nonequidistant modes in the active medium. This hypothesis was verified by insertion into the laser cavity a dispersion compensator consisting of four prisms, which in its proper position ensured equidistancing of modes and thus additionally contributed to stabilization of the laser performance. Narrowing of the spectral width, a linear function of time for a laser with dispersion compensation, ceased after 80-100 ms while the gain decreased in accordance with its being inversely proportional to the square root of time. Figures 3; references 5.

Electron Paramagnetic Resonance in Scanning Tunneling Microscope

937J0010B Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 55 No 10, 10-25 May 92 pp 569-572

[Article by S. N. Molotkov, Institute of Solid-State Physics at Russian Academy of Sciences, Chernogolovka (Moscow Oblast)]

[Abstract] In an experiment with a scanning tunneling microscope reported by A. W. McKinnok (Proceedings, Conference on Scanning Tunneling Microscopy, 1991) on the constant magnetic field was superposed a weak one perpendicular to it rotating at some constant speed, this configuration corresponding to an electron-paramagnetic-resonance (EPR) experiment. The test object was an organic molecule containing free radical centers with localized spins. A lock-in detector was used for measurement of the tunneling current as it varied in time. When the speed of the rotating field was equal to the EPR frequency of a localized at the center, then oscillations of the tunneling current were detected as long as the microscope needle stood above the center of the image and the signal vanished as soon as the needle was moved away from the center of the crystal. This indicates that delocalized electrons at the center and a localized spin at the center have different EPR frequencies. On this premise is proposed a theory explaining the mechanism, if not the principle, of tunneling current modulation. Assuming a speed of the rotating magnetic field close to the EPR frequency of a spin at the center, the time dependence of the tunneling current is calculated analytically, after tunneling from crystal to needle has been described with a Hamiltonian in the basis of localized orbitals and the tunneling current as a function of time then expressed in terms of the two Green-Keldysh spin functions $G^{+-}(t,t')$ (L. V. Keldysh; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, Vol 47, 1964. C. Caroli, R. Combescot, P. Nozieres, and D. Saint-James, JOURNAL OF PHYSICS C Vol 5, 1972). Interaction with a localized spin must be accounted for, but negligible spin-orbital interaction in the crystal can be ignored in the evaluation of these functions. Each is multiplied by the corresponding g-factor and the corresponding Hamiltonian T-term referring to an electron transition from an orbital in the crystal to an orbital in the needle, whereupon the integral of the difference between the two products is traced over orbital and node as well as spin indices. The author thanks B. A. Volkov, S. V. Iordanskiy, and S. S. Nazin for discussions. References 5.

Mechanicals Characteristics of Interaction Processes Involving Laser Radiation of Various Wavelengths and Opaque Materials

937J0024A St.Peterburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 2, Feb 92 pp 84-92

[Article by A. A. Andreyev, V. I. Bayanov, V. I. Kryzhanovskiy, A. G. Samsonov, and N. A. Solovyev]

[Abstract] Interaction of laser radiation and targets made of opaque materials is analyzed, the interaction process being broken down into four stages and being described by a mathematical model which combines several known theories in a way to best fit available experimental data. In the first stage the target surface absorbs the radiation and warms up while heat flows out. In the second stage the target surface heats up till it begins to evaporate and the transparent vapor heats up to its breakdown temperature so that a plasma begins to form. In the third stage there takes place formation of an opaque plasma which then heats up further. In the fourth stage the plasma clears as its density decreases as it expands in a self-consistent mode. The equations describing the process and the attendant mechanical action of vapor or plasma on the target are formulated for a

rectangular incident laser pulse of duration τ carrying radiation of an arbitrary wavelength λ and imparting a thermal flux of intensity q to the target. The outflow of transparent vapor from the target surface is described in the approximation of gas dynamics using the model of an evaporation jump. Evaporation accordingly takes place under conditions of phase equilibrium and a quasi-steady process within the phase transition zone, this zone eventually being replaced by a discontinuity on the surface of which the laws of mass-energy-momentum conservation remain valid. In the third stage the laser radiation interacts with a strongly absorbing plasma, which shields the target surface against further mechanical action and curtails further outflow of vapor while additional heating of the ionized vapor by the absorbed radiation increases somewhat the recoil momentum of the target. In the fourth stage only plasma continues to leave the target surface and expand. Then either the density of the target material jumps from that of a solid material to a level below the critical one for the given radiation wavelength when the intensity of incident radiation is low to moderate ($q < 10$ TW/cm^2), or self-consistent expansion of the plasma is replaced by expansion with a density profile which includes that critical density level when the intensity of incident radiation intensity is high ($q > 10$ TW/cm^2). Following an analytical solution of the respective equations, the dependence of the specific recoil momentum (dyn.s/J) on the energy density of absorbed thermal radiation (J/cm^2) and its time response have been evaluated for an aluminum target treated once with 0.35 μm laser radiation and once with 1.05 μm laser radiation in pulses of 0.7-40 ns duration and 1-60 ns duration respectively. Numerical calculations were made by using the "Slava" (Glory) program, based on a one-dimensional description of the laser action of the target with melting as well as evaporation of the target material taken into account. The authors thank V. A. Rybakov for helpful discussions. Figures 5; references 13.

Using Dynamic Holograms Recorded in Light-Absorbing Gas for Enhancement of Optical Images

937J0024B St Peterburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 2, Feb 92 pp 134-139

[Article by A. M. Berezinskaya and A. M. Dukhovnyy]

[Abstract] Use of dynamic holograms recorded in a light-absorbing gas for enhancement of images of objects illuminated by a laser is shown to solve at least two problems associated with holographic enhancement. One problem is maximizing efficient utilization of the laser energy, which means allowing either a lower photographic recorder sensitivity or a lower laser radiation intensity. This is made feasible by a redistribution of some light illuminating the object into the reference beam on the hologram and subsequent energy transfer to the object beam by interaction of waves on the hologram, the hologram being located between the object and the recorder. Another problem associated with holographic image enhancement is lowering the threshold signal level, which requires lowering the intensity of inherent noise in the image-enhancing hologram relative to the noise intensity in the recorder. An experiment with specularly reflecting and diffusely scattering objects was performed for the purpose of comparatively evaluating their holography with and without a dynamic hologram recorded in a light-absorbing gas. The light source was a single-mode Nd-glass laser with a frequency doubler emitting 0.53 μm second-harmonic radiation in pulses of 25-30 ns duration in a beam 4 mm in diameter. Reflecting holograms were recorded dynamically with frequency-degenerate light beams at a 177.5° convergence angle in a gaseous NO_2 + Xe mixture filling a 5 cm long cell with a 0.40 transmission coefficient for 0.53 μm radiation. The energy density of the reference beam was held constant at 0.35 J/cm^2 throughout the experiment. Recording of enhanced and unenhanced images was done simultaneously on VRP-grade Gd-Ag industrial photographic plates. The optical apparatus for this experiment also included four glass wedges, four totally reflecting plane mirrors, a stack of three light filters, two diffusely reflecting mirrors, two right-angle prisms, and one biconcave lens. Measurements were made which yielded data for evaluating the dependence of the hologram diffraction efficiency and of the reconstructed image contrast on the energy density of the object beam during recording of the images of both kinds of objects with and without holographic image enhancement each. The results confirm the effectiveness of this method in widening the range of recordable light intensity downward by more than two orders of magnitude. The authors thank A. L. Churayev for helpful discussion. Figures 3; references 12.

Reflection of Electromagnetic Waves by Surface With Fine Random Relief

937J0030A St Peterburg OPTIKA I SPEKTROSKOPIYA in Russian Vol 72 No 3, Mar 92 pp 660-665

[Article by R. Z. Vitlina, Institute of Semiconductor Physics Russian Academy of Sciences, Siberian Department, Novosibirsk; UDC 535.39.01]

[Abstract] Reflection of electromagnetic waves by randomly rough surfaces is considered, of concern being the effective dielectric permittivity tensor ε. The random function f(x,y) describing the surface relief has a zero mean but a finite dispersion s^2, its characteristic dimensions being l_x and l_y in the respective orthogonal directions. Mild roughness implies that both dimensions and the dispersion are much smaller than the wavelength of incident electromagnetic radiation. The fields at the surface are calculated in the quasi-static approximation with curl E = div D = 0 and D = ε(x,y,z)E within the H-zone. For surfaces with shallow three-dimensional roughness the tensor components are calculated by the method of perturbation theory. In this case ε_{xx}, ε_{yy}, and ε_{zz} are each different. For surfaces with steep two-dimensional roughness the tensor components are calculated with the aid of the analogy between dielectric permittivity and electrical conductivity, assuming also that the slope df(x)/dz is almost zero and the asperities can be regarded as an array of plane-parallel fins. In this case $\varepsilon_{xx} = \varepsilon_{yy}$ and ε_{zz} is different. References 6.

Effect of Back-Scattering on Time Coherence of Laser Radiation

937J0031A St Peterburg OPTIKA I SPEKTROSKOPIYA in Russian Vol 72 No 4, Apr 92 pp 940-941

[Article by M. N. Dubrov and V. A. Aleshin, Institute of Radio Engineering and Electronics at Russian Academy of Sciences, Fryazino; UDC 621.373:535+535.36]

[Abstract] An experimental study was made concerning the frequency shift of stabilized He-Ne lasers in long-base Michelson interferometers with two unequally long arms. It has already been established that reflection by optical components, their distances L from the laser ranging from 1 m to 1000 m, is a source of feedback and that a continuous variation of distance L causes the laser frequency to oscillate with a period which corresponds to half the radiation wavelength. The amplitude of these oscillations has in earlier experiments been, however, overestimated by a factor of about 1000. In this experiment the frequency oscillations were found to become more nonsinusoidal as the ratio of distance L to length l of the laser cavity increased, even though the relative back-scattering intensity remained at the same low level of 10^{-8}, and saw-tooth oscillations were found to indicate a critical feedback condition. Inasmuch as small changes of distance L from laser to scatterer usually noncontrollable, the attendant optical feedback evidently limits the momentary frequency stability of such a laser and thus also the time coherence of the emitted radiation during operation with remote objects. Random fluctuations of the distance to the object of measurements or to the photodetector owing to acoustic, thermal, or other noise, can thus cause a broadening of the laser emission line by as much as 10^{-7} %. Figures 1; references 6.

Interaction Between Powerful Flows of Accelerated Plasma of Ultrahigh Pressure Discharge From Surface of Electrodes

927J0246A Moscow IZVESTIYA AKADEMII NAUK RAN: SERIYA FIZICHESKAYA in Russian Vol 56 No. 6, Jun 92 pp 141-149

[Article by I. V. Tsvetkov, Moscow Physical Engineering Institute; UDC 533.924]

[Abstract] The processes transpiring during interaction between powerful flows of accelerated plasma in an ultrahigh pressure discharge and electrode surfaces were simulated. The principal reasons for electrode erosion are clarified. A closed self-consistent model relating erosion, the acceleration process and the behavior of arc plasma is proposed. Simple evaluations show that the erosion of electrodes in the solid phase and also erosion under the influence of thermoelastic stresses and erosion in the gaseous phase (evaporation) is negligible in comparison with erosion in the liquid phase. Most of the metal on the surface of electrodes subjected to the impact of arc plasma is in a liquid state and the transfer of the greater part of the material from the electrodes occurs in the liquid phase. The loss of liquid metal also is the principal channel for conveyance of heat from electrode surfaces. The proposed model can be used in computing the rate of destruction of electrodes of any metal, for calculating the thickness of a layer of any coating on the working surface of electrodes and for determining the optimum change in thickness of the coating along the length of a channel in apparatus with arbitrary parameters of both the electric circuit and the structure as a whole (geometry, materials). Figures 7; references 8: 3 Russian, 5 Western.

Explosive Crystallization in Laser-Precipitated Films

927J0246B Moscow IZVESTIYA AKADEMII NAUK RAN: SERIYA FIZICHESKAYA in Russian Vol 56 No 6, Jun 92 pp 150-156

[Article by A. V. Zenkevich, V. N. Nevolin, O. B. Uvarov and I. D. Khabelashvili, Moscow Physical Engineering Institute; UDC 533.924]

[Abstract] Research was carried out on structure formation in laser-precipitated films. An Ni-Si system was chosen because it was possible to make comparisons with data in the literature; an Fe-Si system was selected from methodological considerations due to the tendency of iron-based structures to amorphization. The apparatus, methods and materials used in the research are described. In a study of Ni-Si films laser precipitated on a Si_3N_4/100, Si and Fe on 100 Si at room temperature, it was discovered that in the precipitation stage the formation of epitaxial layers of nickel silicide occurs on an amorphous backing, and the formation of iron silicide with a thickness up to 400 A is observed. The results reveal that the structure of the films is formed as a result of explosive crystallization of the nonequilibrium layers forming in the precipitation stage. The initially amorphous layers, as a result of the great rates of precipitation and the accompanying bombardment of the surface by particles with an energy up to 1 keV, relax in an "avalanche" mode with the release of heat adequate for the formation of an ideal crystalline layer, resulting in interaction between the film and its backing with formation of a silicide layer. Figures 8; references 11: 5 Russian, 6 Western.

Dynamics of and Radiation Emission by Relativistic Electron Beam in Vacuum Resonator Cavity in Absence of Magnetic Field

927J0271A Moscow FIZIKA PLAZMY in Russian Vol 18 No 7, Jul 92 pp 850-856

[Article by P. V. Koteteshvili, A. A. Rukhadze, P. V. Rybak, and V. P. Tarakanov, Institute of General Physics at Russian Academy of Sciences; UDC 533.951]

[Abstract] The author's study of a relativistic electron ribbon-beam injected through a conductor foil into plane resonator cavity is continued with an analysis of the beam injection dynamics over a period of time much longer than taken by such a beam to cover the entire cavity length. The analysis is based on Maxwell field equations and Vlasov equation of kinetics, the former being solved by means of a difference scheme on shifted grids and the latter being solved by method of macroparticles. The analysis is then completed by an evaluation of the results of a numerical experiment yielding the 2D and 3V dimensionalities in a plane Cartesian system of coordinates XZ. The mathematical model, written down in the KARAT-XZ code, takes into account all particle momentum components and all electromagnetic field components by assuming that these quantities are functions of not only the transverse y-coordinate but also of the longitudinal z-coordinate and the transverse x-coordinate. The results pertain to injection of a 2 cm thick relativistic electron beam carrying a current of 1 kA/cm and an energy of 2 MeV along the plane of symmetry in a 10 cm thick and 30 cm long cavity, the cavity being open at the opposite end for extraction of radiation emitted by the beam in the form of a plane wave while the beam is deflected toward its lateral walls by means of a local magnetic mirror with an H_y which begins to increase at some point along the longitudinal Z-axis. On this basis have been calculated the trajectories of beam particles in the lateral XZ plane, also the distributions not only in this plane but also in the lateral YZ plane and in various successive XY planes perpendicular to the beam at several successive instants of over a 20 ns period following injection. The results indicate that interaction of such an electron beam with a priori given modes of a TM-wave produces modes of which only the three $TM_{21,22,23}$ modes are unstable in a plane geometry. The efficiency of radiation emission by such a beam is calculated by equating the H_y field component of the TM_{zz} mode which has been generated on the beam surface to the magnetic field of the beam current. The authors thank N. F. Kovalev for discussing the results. Figures 8; references 2.

Excitation of Coaxial Retarding Plasma Structure in Cerenkov Plasma Amplifier Into Fundamental Mode by High-Current Relativistic Electron Beam

927J0271B Moscow FIZIKA PLAZMY in Russian Vol 18 No 7, Jul 92 pp 857-868

[Article by I. A. Selivanov and A. G. Shkvarunets, Institute of General Physics at Russian Academy of Sciences; UDC 533.951.2]

[Abstract] Transport of pulsed high-power microwave radiation through an oversize coaxial plasma waveguide was studied in an experiment under conditions favoring excitation of only amplitudinally symmetric modes and thus under conditions necessary for realization of a Cerenkov plasma amplifier by means of a relativistic electron beam. The apparatus included a TEM-mode exciter, two parallel waveguides for injection of microwave power, the cathode of a plasma source generating a tubular plasma column, a plasma collector, a cylindrical microwave radiation absorber passing through the plasma column at the collector end, a shielding tube around the plasma column, a coaxial waveguide for extraction of microwave power, and a set of supporting straps. The coaxial TEM-mode exciter consisted of four rectangular waveguides inserted into a coaxial metal-tube waveguide which had been split into four sectoral compartments by three metal shelves, this composite waveguide being joined through a transition piece to a coaxial waveguide with a center conductor whose end piece served as the plasma collector. Microwave radiation of 2.42 cm wavelength was generated by a magnetron in pulses of 10-100 μs duration carrying a power of up to 150 kW. This radiation was, by means of three wideband slotted-waveguide bridges, split into four equal parts passing each through another one of four rectangular waveguide "arms" with a 1:1:1:1 power ratio on the output side. The method used for phasing the TEM-mode exciter was to vary the lengths of these waveguide arms. The power of the microwave radiation could be attenuated stepwise from 150 kW to as far down as 12 kW by changing the power distribution among the slotted-waveguide bridges stepwise from 1:1 to as far down as 1:10 on the output side. The plasma density was measured upon replacement of the TEM-mode exciter with a rectangular waveguide connecting two opposite arms and crossing the tubular plasma column so as to act as the plasma collector. This waveguide, however, included a 0.4 cm long gap which let a part of the plasma column pass through. For plasma probing was used electromagnetic radiation in the TE_{10}-mode of this waveguide, its electric field vector being in this configuration oriented parallel to the external magnetic field. The plasma was probed with this electromagnetic radiation at three wavelengths: 2.42 cm, 0.80 cm, 0.65 cm. In this way the dependence of the plasma density on the discharge current in the plasma source was determined for the (2-50) x 10 cm^{-3} wide range of plasma density. The results of the experiment are supplemented with results of numerical calculations based on an approximate theory: 1) the transmission coefficient characterizing passage of microwave radiation through a plasma layer, calculated in the approximation of a plane monochromatic electromagnetic wave normally incident on a thin plasma layer; 2) the dispersion characteristics of a circular waveguide partly occupied by a thin tubular plasma column in an infinitely strong magnetic field (J. S. De Groot, R. A. Stone, K. Mizuno, et al; IEEE Transactions on Plasma Science, Vol 16, 1988). Transport of microwave radiation through a coaxial plasma waveguide in a finite magnetic field is then analyzed on the basis of all available relevant data. Transport of high-power microwave radiation power through such a waveguide upon excitation of the plasma into its fundamental mode with a high-current relativistic electron beam then shown to be feasible: 100-150 kW of monochromatic microwave radiation can evidently be transported in this way through a 30 cm long tubular plasma column in 0.4 μs. Figures 9; references 11.

Recording Magnetic Fields in High-Current Z-Pinch With "Angara-5-1" Apparatus by Faraday Rotation Method

937J0013A Moscow FIZIKA PLAZMY in Russian Vol 18 No 9, Sep 92 pp 1131-1137

[Article by A. V. Branitskiy, V. D. Vikharev, A. G. Kasimov, S. L. Nedoseyev, V. P. Smirnov, and V. Ya. Tsarpin, Institute of Atomic Energy imeni I. V. Kurchatov, A. A. Rupasov, G. S. Sarkisov, and A. A. Shikanov, Institute of Physics imeni P. N. Lebedev at Russian Academy of Sciences, Moscow; UDC 533.951]

[Abstract] Magnetic fields in the plasma of a high-current Z-pinch were measured by the Faraday rotation method using the Angara-5-1 test facility. The principal components of the apparatus for this experiment were an eight-stage 12 TW current generator designed to produce a 6.5 MA current pulse of 90 ns duration at a 2 MV high voltage, the Luch-2 set for optical diagnostic measurements, and a polarimeter-interferometer for magnetic measurements. The specially built Luch-2 set consisted of a Q-switched ruby laser oscillator emitting 694 μm radiation pulses of about 100 mJ energy and about 1 ns duration, a Pockels cell for shortening the pulse duration, a laser discharger, and two two-pass laser amplifiers. The polarimeter-interferometer consisted of three channels for simultaneous recording and subsequent analysis of three plasma images: Faraday, interference, and shadow images. Its optical system included two crossed polarizers, each one a wide-aperture (30 x 30 mm^2 Glan prism with a 3.2 x 10^{-5} nominal and 1 x 10^{-4} actual contrast ratio). The plasma cell was placed inside a spherical vacuum chamber on the optical axis between two windows, the entrance window facing the first polarizer prism and the exit window facing the second polarizer prism behind three planoconvex lenses with a diaphragm before the middle one. An obliquely set 5° glass wedge in front of the second polarizer prism diverted two separate light beams for recording on a separate photographic film each. The first beam reached the first photographic film after reflection by a plane mirror and subsequent passage through a color-glass filter. The second beam reached the second photographic film after reflection by another plane mirror and subsequent passage through a perpendicularly set 3° Iceland spar wedge and a polarizer film prior to passage through a color-glass filter. A set of two plane mirrors behind the second polarizer prism reflected the main light through a color-glass filter onto a third photographic film. An analysis of the data revealed an intricate structure of plasma Z-pinch passing the main current, with cumulation of matter in it and with random radial plasma excursions, the consequently intricate profile of electrical conductivity giving rise to secondary currents circulating inside the plasma. The experiment was set up so as to favor large gradients of plasma concentration, which complicated optical measurements with a probing laser beam but also facilitated spreading of plasma clusters and thus provided a magnetically active medium very convenient for current and magnetic induction measurements. The authors thank the Angara-5-1 facility staff for setting up the experiment and O. N. Krokhin for helpful discussions. Figures 4; references 15.

Parametric Cerenkov Instability of Relativistic Electron Beam in Periodically Nonhomogeneous Dissipative Medium

937J0013B Moscow FIZIKA PLazmy in Russian
Vol 18 No 9, Sep 92 pp 1166-1173

[Article by A. V. Baytin, A. A. Ivanov, and K. S. Serebrennikov, Institute of Atomic Energy imeni I. V. Kurchatov; UDC 533.9]

[Abstract] Parametric instability of a relativistic electron beam arising during its Cerenkov interaction with a decaying slowed-down electromagnetic wave near the boundary of the Brillouin zone in a dissipative medium (crystal) with a periodic profile of its dielectric permittivity is analyzed, the frequency of the electromagnetic wave ω being sufficiently higher than the plasma frequency of the medium for regarding that medium as one with a modulated plasma frequency. The dielectric permittivity of the medium is ε(ω,r) is the sum of two components: frequency-dependent complex permittivity of a homogeneous wave-attenuating medium $\varepsilon_2(\omega) = \varepsilon_0(\omega) + i\varepsilon_0'$ depending on the frequency only and permittivity of the reciprocal lattice $\Sigma \varepsilon_{ql} e^{ilqr}$ (q - vector of reciprocal lattice, r - radius, l = +/- 1, +/- 2,...). The electron beam, its dielectric permittivity being a tensor quantity, induces waves in the medium so that another interaction takes place in such a medium. From the equations of motion and continuity for its particles and Maxwell's field equations is obtained, with the aid of Floquet's theorem, the dispersion equation for the space-charge waves of an electron and the fundamental-frequency component of an electromagnetic wave field interacting in such a medium. Calculations for a monoenergetic homogeneous electron beam reveal that its instability increment in such a medium depends on its transverse wave number and on the angle between the direction of its propagation and the vector of the reciprocal lattice. The results based on a direct numerical solution and on a prior analytical solution of that dispersion equation were found to differ only by factor close to unity. They indicate that the increment of parametric Cerenkov electron beam instability and the threshold current density for this instability in a medium with a periodic spatial permittivity distribution ultimately depend on the characteristics of the medium and specifically a certain characteristic crystal dimension. This dimension is the length of the path of beam scattering in the crystal, namely of the path over which the beam velocity distribution becomes so widely spread that transition to kinetics will take place with an attendant instability cutoff. This implies that a crystal must be sufficiently thick for parametric Cerenkov instability of a relativistic electron beam in it to develop. An at least 1 mm thick LiH crystal is considered as an example. Figures 3; references 18.

Radiation Source of Liner Type for Pumping Short-Wave Al-Mg Laser

937J0014A Moscow FIZIKA PLAZMY in Russian
Vol 18 No 6, Jun 92 pp 688-697

[Article by R. B. Baksht, I. M. Datsko, V. A. Kokshenev, A. V. Luchinskiy, V. V. Loskutov, V. I. Oreshkin, and A. G. Russkikh, Institute of High-Current Electronics at Siberian Department, USSR Academy of Sciences, Tomsk, M. O. Koshevoy, A. A. Rupasov, D. A. Fedin, and A. S. Shikanov, Institute of Physics imeni P. N. Lebedev at USSR Academy of Sciences, Moscow; UDC 533.916]

[Abstract] In an experimental study of the optically pumped AlXl-MgIX 4.8338 nm laser implosion of a multiwire liner was used for generating a sufficiently hot aluminum plasma column capable of evaporating a magnesium target, this resonantly coupled ion pair being a possible short-wave laser but requiring extremely high pumping energy from a high-intensity radiation source. The experiments were performed with 3 cm long aluminum liners having 0.5-1.4 cm large initial diameters and a linear density of 160-240 μg/cm. Currents of 1.2-1.5 MA magnitude with an 80-100 ns rise time were sent through these liners from a a GIT-4 inductive energy storage through a plasma-type current chopper. Emission of soft X-rays was analyzed with the aid of photoemission X-ray vacuum diodes and a camera obscura, and a spectrograph using a transmissive diffraction grating. Spectrograms were recorded on two different X-ray films: RAR 2497 and Kodak 101-01. The main problem had been to ensure adequate compression of the aluminum liners and thus also of the individual plasma columns impinging on the wires, which was achieved by proper matching and configurations either with the liner inside the generator diode and without a current return path or with the liner inside a 4 cm in diameter tubular current return conductor. The experiment has yielded liner obscurograms and isodensitograms as well as aluminum emission spectra. The spectra have been both analyzed statistically and evaluated theoretically, with the Doppler effect necessarily taken into account. The results indicate that an about 10 GW/cm pumping power density necessary for lasing inversion is achievable by compression of multiwire aluminum liners with a current of 1.3-1.5 MA. Radiation emission by such these liners was found to be very nonuniformly distributed over their length, evidently owing to formation of hot spots. Figures 6; tables 2; references 13.

Dependence of Tokamak Density Limit Criterion on Material of First Wall

937J0014B Moscow FIZIKA PLAZMY in Russian
Vol 18 No 6, Jun 92 pp 799-801

[Article by A. V. Gruzinov and O. P. Pogutse, Institute of Atomic Energy imeni I. V. Kurchatov; UDC 533.9.082]

[Abstract] Following replacement of the carbon wall in the JE tokamak with a beryllium one, the criterion for the plasma density limit was found to have changed from poloidally symmetric cooling of the plasma pinch with its attendant stiff breakdown at the critical charge concentration to asymmetric marfe cooling around a small contour (S. Clement et al.; Proceedings, 17th European Conference on Controlled Fusion and Plasma Heating, Part 3, 1990). The model proposed by O. P. Pogutse (O. P. Pogutse et al.; Proceedings, 17th European Conference on Controlled Fusion and Plasma Heating, Amsterdam/Netherlands 1990) adequately explains this transition from one to another manifestation of the plasma density having reached its limit. The model is based on three premises: 1) both marfe breakdown and stiff breakdown are consequences of thermal instability within the boundary region at the tokamak wall, where radiation emission intensifies as the temperature falls; 2) both parallel and transverse thermal

fluxes have a stabilizing effect, neither of them being negligible; 3) only carbon and beryllium glow. A key relation then underlying this model is the dependence of the transverse thermal diffusivity on the poloidal angle in an inverse relation, probably a consequence of its similar dependence on the magnetic induction. The equation for the temperature based on this model covers both breakdown modes, the Drake effect having been ignored but both parallel and transverse thermal diffusivities being involved. The plasma density limit is theoretically shown to be determined by the characteristic radiation temperature of impurities, light impurities (lower radiation temperatures) giving rise to marfe breakdown and heavy impurities (higher radiation temperatures) giving rise to stiff breakdown. This agrees with experimental evidence that the probability of marfe breakdown increases with lower impurity radiation temperature. The breakdown mode is shown to depend on the ratio of anomalous transverse thermal to parallel thermal diffusivities. Two different values of this ratio accordingly correspond to different breakdown modes at the plasma density limit, its border value being obtained from the condition that the parallel heat transfer is then equal to the excess over stabilizing transverse heat transfer. Theoretical estimates of the critical temperature for the JE tokamak, made on the assumption that the stabilizing transverse thermal diffusivity is constant but that both the anomalous transverse thermal diffusivity and the parallel one depend on the charge concentration as well as on the temperature, are found to also agree with experimental evidence. References 4.

Interaction of Relativistic Electron Beam and Bremsstrahlung Converter in Pinch-Effect Diode

937J0028A Moscow FIZIKA PLAZMY in Russian
Vol 18 No 10, Oct 92 pp 1296-1302

[Article by V. F. Zinchenko, V. D. Shiyan, and V. V. Timofeyev, Scientific Research Institute of Devices; UDC 621.384.64]

[Abstract] Interaction of a relativistic electron beam and a thin target converting beam energy into bremsstrahlung energy converter in a pinch-effect accelerator diode is analyzed numerically, concerning the effect of the electric field in the diode and of the intrinsic magnetic field of the beam current on the energy absorption by the target and on the bremsstrahlung yield. Calculations were made for a beam of 1 MeV electrons carrying a current of 500 kA in pulses of 40 ns duration and a tantalum target subject to explosion by heat placed on the anode. The azimuthal and radial current density distributions over the target surface are assumed to be isotropic and Gaussian respectively, the radius of the beam being 0.2 cm long. In the one-electron approximation, the optimum converter thickness would be about 130 μm. The transport of electrons through such targets along a helical path in the magnetic field of the beam current was simulated according to the Goudsmit-Saunderson multiple scattering theory, using the Monte Carlo method for clustered collisions with formation of δ-electrons and fluctuation of ionization losses also taken into account. The equation of state for the tantalum plasma was based on the Thomas-Fermi atom model and the kinetic coefficients were calculated according to Kalitkin's semiclassical theory (N. N. Kalitkin, 1978). The results of numerical calculations for high-current pinch-effect diodes operating at maximum current density levels indicate that the motion of relativistic electrons through such diodes is similar to their drift in crossed electric and magnetic fields. The initial target thickness, density, and temperature were assumed to be 50 μm, 16.6 g/cm^2, and 5 eV respectively. Calculations on this basis have yielded nearly linear velocity profiles of the expanding tantalum plasma across the target thickness at several successive instants of time after beginning of an incident current pulse. The histograms of plasma density profiles and plasma temperature profiles indicate maximum density and minimum temperature at or about the center line of the target. Calculations based on theoretical relations describing electron ballistics in a target and on applicable equations of one-dimensional gas dynamics describing plasma expansion have yielded: 1) the fraction of beam electrons passing through and beyond the target, namely its dependence on the time after the beginning of an incident current pulse; 2) the bremsstrahlung spectra at various distances behind the target; 3) the forward yield of bremsstrahlung energy covering the entire photon energy range, namely its dependence on the initial converter thickness; 4) the efficiency of forward energy conversion covering the < 100 keV photon energy range, namely its dependence on the initial converter thickness. The calculations were made in the one-electron approximation as well as with the recovering action of the diode field and with the converter in the magnetic field taken into account so as to reveal their effect of the converter performance. Figures 6; references 13.

Double Layer Formed by Relativistic Electron Beam

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Vol 18 No 10, Oct 92 pp 1310-1316

[Article by V. I. Maslov, Kharkov Institute of Engineering Physics at Ukrainian Academy of Sciences; UDC 533.9.01]

[Abstract] Formation of a double layer at the plasma boundary upon injection of a relativistic electron beam into a plasma of comparable density is analyzed, this double layer then reflecting the electron beam back toward its source. The source of the electron beam is assumed to be contiguous to the plasma and no external compensation of its positive charge is assumed to be available. While the electric field accelerates plasma electrons, those near the boundary accelerate very weakly and those inside near the region where reflection takes place to a velocity approaching the beam velocity, there the concentration of plasma electrons becomes much lower than the concentration of beam electrons so that the plasma current opposing the injected beam current remains smaller than the latter and does not compensate the buildup of positive charge in the beam source. It is the returning beam which does the compensation, the potential fall having become equal to its kinetic energy. The process is analyzed in the one-dimensional approximation, valid when both beam and plasma are magnetized. The analysis is based on Vlasov's and Poisson's equations for the electron distribution function and the potential of the double layer respectively, a plasma half-space being considered into which a fast electron beam and a group of slow electrons velocity are injected. These two equations together with the two equations of energy and momentum balance yield a power-law concentration profile of plasma electrons, a power-law concentration profile of

fast beam electrons, and an exponential concentration profile of slow electrons matching their nonrelativistic dynamics. The width of the double layer is obtained, approximately, from the equation describing its potential profile and found to be proportional to $\gamma = [1 - (v/c)^2]^{-1/2}$ when $\gamma >> 1$ ($v = v_b - v_c + v_{Tb}$, v_c - initial velocity of plasma electrons, v_b - velocity of beam electrons, v_{Tb} - thermal velocity of beam electrons. Acceleration of ions through the electric field of the double layer is included in the analysis. Injection of a fast electron beam alone into a plasma is considered next, in which case a double layer is formed too soon for plasma electrons to be sufficiently accelerated by the electric field and thus to move through the entire width of this layer. The potential profile of the slowly moving double layer then becomes a nonmonotonic one with a hump where $n_e(t) < n_i - n_b$ (n_e - variable in time concentration of plasma electrons, n_b - concentration of beam electrons, n_i - ion concentration). A stability analysis of the motion of electrons through this region reveals that perturbations with a phase velocity equal to the initial velocity of plasma electrons v_c make the double layer unstable when the concentration of its electrons falls below a certain critical level. Even a small group of slow electrons will then make the double layer quasi-static. Double layers are classified according to three criteria: 1) according to the mechanism of formation: into a turbulent one, a monotonic one one with a potential well in the low-potential region reflecting some moving electrons, one with a potential hump in the high-potential region reflecting resonance ions; 2) according to the direction of current flow relative to the direction of the electric field vector: into a forward one where their directions are opposite and a reverse one where their directions coincide; 3) according to the kind of particles: into an electronic one with insignificant perturbation of the ion concentration and an ionic one with significant perturbation of the ion concentration. References 7.

Phase Transitions in Vortex Lattices of Hexagonal Exotic Superconductors

927J0279A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 101 No 6, Jun 92 pp 1978-1999

[Article by A. S. Melnikov, Institute of Physics imeni P N. Lebedev at Russian Academy of Sciences]

[Abstract] A theory of magnetic phase transitions in hexagonal exotic superconductors such as UPt_3 is proposed, the order parameter in this case having two complex components (1 + i;1 - i). First is formulated the Ginzburg-Landau energy for such superconductors in a magnetic field, only phases which in the absence of a magnetic field violate the invariance with respect to time reversal being then considered. The structure of a vortex lattice in a magnetic field parallel to the hexagonal axis of symmetry and of an intensity close to the upper critical, the upper is then described, using the solution to the linearized Ginzburg-Landau equations and the expression for that upper critical magnetic field (M. Ye. Zhitomirskiy; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 49, 1989 p 333). Changes in this structure as the magnetic field decreases to the upper critical level are then analyzed by reference to the Ginzburg-Landau functional in a form implicitly involving two parameters C and b. In a magnetic field of intensity near the upper critical this functional describes a regular triangular or rectangular lattice of one-quantum vortices with approximately circular unit cells. As the intensity of the magnetic field decreases, various phase transitions can take place depending on the values of those parameters in the energy functional. When those parameters are small and the magnetic field is still strong, then the transition is from a regular triangular one-quantum lattice to a nonsingular one formed by one-quantum vortices. As the intensity of the magnetic field decreases, the transition from a one-quantum lattice to a lattice of two-quantum vortices with also approximately circular unit cells takes place within the widest range of b and C values. The occurrence of such a transition has been confirmed experimentally. There are three ranges of b and C within which the energy of a two-quantum lattice is so close to the energy of a rectangular one-quantum lattice that a further small decrease of the magnetic field intensity will make a two-quantum lattice energy-wise preferable, estimates based on calculations by the Wigner-Seitz method thus having correctly predicted existence of a two-quantum lattice also in a magnetic field of intensity near the upper critical. In a superconductor with a Ginzburg-Landau constant $\kappa >> 1$, however, in such a magnetic field a one quantum lattice is energy-wise preferable so that evidently a reverse transition from a two-quantum lattice to a one-quantum lattice takes place in such a superconductor as the intensity of the magnetic field decreases within the range where the intervortex distance d is much larger than the coherence length ξ but smaller than the field penetration depth λ. The author thanks Yu. S. Barash for guidance, G. Ye. Volovik for helpful comments, and M. Ye. Zhitomirskiy for making the results of his study (M. Ye. Zhitomirskiy, I A. Lukyanchuk; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 101 No 6, 1992) available. Figures 6; references 23.

Single Crystals of Organic Superconductor Material k-(BEDT-TTF)$_2$Cu [N(CN)$_2$]Br: Critical Currents, Magnetization Curves, and Flux Creep

927J0279B Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 101 No 6, Jun 92 pp 1945-1953

[Article by V. V. Metlushko, Moscow State University imeni M. V. Lomonosov, V. D. Kuznetsov, Moscow Institute of Chemical Technology imeni D. I. Mendeleyev, L. A. Yepanechnikov, Ye. F. Makarov, Ye. B Yagubskiy, and N. D. Kushch, Institute of Chemical Physics imeni N. N. Semenov at Russian Academy of Sciences]

[Abstract] An experimental study of k-(BEDT-TTF)$_2$Cu [N(CN)$_2$]Br superconductor single crystals was made concerning the field-temperature dependence of their critical current. This organic superconductor material was produced by oxidizing 0.002 mole/l of BEDT-TTF in 1,1,2-chloroethane solution with 2 percent absolute ethanol on a platinum anode at a constant current of 0.5 μA, the 18-crown-6 complex with a 0.002 mole/l solution of 1:1 solution of NaN(CN)$_2$ + CuBr being used as the electroiyte. Two crystals of different sizes, one 0.05 x 0.68 x 0.75 mm^3 and one 0.13 x 0.5 x 0.68 mm^3, were mounted into the lateral wall of a quartz flask, the latter then having been evacuated and filled with spectrally pure helium under a pressure of about 20 torr. Relaxation of the magnetic moment was measured while a magnetic field was applied at rates of about 1-10 T/s and magnetization curves were plotted with the magnetic field swept at a rate of dB/dt ≈ 0.0001 T/s. The temperature dependence of the magnetic moment was measured in the zero-field-chilling mode (residual magnetic field of the order of 10 μT) with subsequent application of a magnetic field B and then with chilling in this magnetic field B. Magnetization curves were plotted at several temperatures in a magnetic field first perpendicular and then parallel to the plane of current conduction. Those plotted in a perpendicular magnetic field were found to be characteristic of a type-2 superconductor. Those plotted in a parallel magnetic field were found to be completely reversible at T = 4.2 K already, indicating absence of shielding currents, and not to change as the temperature was raised. From these curves was evaluated the field dependence of the magnetic moment. An analysis of the their irreversible segments in a perpendicular magnetic field based on Bean's model (C. P Bean; REVIEW OF MODERN PHYSICS Vol 36 p 31, 1964) has yielded an exponential field-temperature dependence of the critical current density j_c(B,T), also with a pronounced anisotropy. Relaxation measurements in the zero-field-chilling mode in magnetic fields of various intensities showed the magnetic moment to be a logarithmic function of time only in a magnetic field of intensity lower than 3 mT. The authors thank A. A. Zhukov for helpful comments. Figures 7; references 15.

Anomalous Pressure Dependence of Critical Parameters of Organic Superconductor Material $(ET)_4Hg_{2.89}Br_8$

927J0279C Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 101 No 6, Jun 92 pp 1841-1845

[Article by S. L. Budko, A. G. Gapotchenko, and A. Ye Luppov, Institute of High-Pressure Physics, R. N

I.yubovskaya and R. B. Lyubovskiy, Institute of Chemical Physics, Russian Academy of Sciences]

[Abstract] An experimental study of $(ET)_4Hg_{2.89}Br_8$ superconductor single crystals was made concerning the field-pressure dependence of their critical parameters. Rhombic single crystals of this organic superconductor material were grown by electrochemical oxidation from an ET solution in trichloroethane, as the electrolyte being used $k(n\text{-}Bu_4NHgBr_3 + HgBr_2)$. Temperature dependence measurements were made under hydrostatic pressure, in two ways: 1) for the electrical resistance R(T) under pressures up to 34 kbar by the current-voltage method with a constant current; 2) for the magnetic susceptibility $\chi(T)$ in a magnetic field of up to 20 kOe and under pressures up to 16 kbar by the inductive method at modulation frequencies of 330 Hz to 100 kHz, with the external magnetic field and the modulating magnetic field perpendicular to each other. The temperature of superconducting transition onset was identified on the $Re\chi(T)$ curve. In this way the temperature dependence of both electrical resistance and upper critical magnetic field under various pressures, the pressure dependence of both critical superconducting transition temperature and upper critical magnetic field, and the dependence of the critical temperature in a constant magnetic field on the modulation frequency under various pressures were obtained. Inasmuch as the pressure dependence of the critical temperature of many organic superconductors in the ET group is known to be linear, an extrapolation of the critical temperature in zero magnetic fields indicates that in single crystals of this particular material superconducting transition will not take place under a pressure of 21 kbar already. The authors thank S. I. Pesotskiy for helpful discussions. Figures 5; references 12.

Thermal S → N Transition Stimulated in Thin Superconductor Film by Incident Electromagnetic Radiation

927J0283A Moscow SVERKHPROVODIMOST': FIZIKA KHIMIYA, TEKHNIKA in Russian Vol 5 No 3, Mar 92 pp 419-422

[Article by A. A. Zharov, A. L. Korotkov, and A. N. Reznik, Institute of Applied Physics at Russian Academy of Sciences, Nizhniy Novgorod]

[Abstract] Transition of superconducting films to the normal state during exposure to electromagnetic radiation is analyzed theoretically on the basis of heat balance attending the rise of temperature. A thin film of a superconductor material (thickness d, width w) is assumed to lie between a nonabsorbing substrate (thickness L, dielectric permittivity ε_s) and a dielectric medium (permittivity ε), the other surface of the substrate having been thermally stabilized at a temperature T_0 lower than the critical superconducting transition temperature T_c for the film material and an electromagnetic wave in the dielectric medium impinging normally on the film. For a uniform temperature distribution over the film, with $k/d >> k_s$ and $cd << c_sL$ (k,c - thermal conductivity and specific heat of film material, k_s,c_s - thermal conductivity and specific heat of substrate material), the equation of heat balance is formulated according to R. J. Keyes (1977) so as to include the temperature-dependent absorption coefficient of the film material and the thermal conductivity G of the film-substrate interface as well as the heat capacity C of the film-substrate structure and the power P of incident radiation P. For a structure where L (substrate thickness) >> w (film width) the equation of one-dimensional heat conduction under a constant thermal flux at one surface and a constant temperature at the other surface this equation yields $G = k_s/L$ and $C = c_sL/2$. The expression for the absorption coefficient of the film material is formulated in accordance with the two-fluid model of a superconductor with a complex electrical conductivity, the temperature dependence of both hole and electron concentrations in the film then being ignored and a film being considered whose thickness is much smaller than the skin-effect depth. The absorption coefficient and also the reflection coefficient are then calculated as functions of the dimensionless temperature rise $(T - T_0)/(T_c - T_0)$, both the temperature rise and the reflection coefficient in turn depending on the power of incident radiation in a manner characterizing a bistable device. On this basis is now calculated the threshold power of incident radiation necessary for S → N switching of such films. It has been calculated numerically for $YBa_2Cu_3O_x$ and incident electromagnetic radiation covering the 10^5 - 10^6 MHz range. Figures 2; references 14.

Dependence of Plasticity Characteristics of Ceramic Material on Water Content in Powder

927J0284A Moscow SVERKHPROVODIMOST': FIZIKA KHIMIYA TEKHNIKA in Russian Vol 5 No 2, Feb 92 pp 356-363

[Article by E. T. Mogilko, A. A. Puzanova, D. I. Voronov, Yu. G. Litvinenko, I. V. Pulyayeva, G. Kh. Rozenberg, and V. V. Usenkova, All-Union Scientific Research Institute of Single Crystals, Kharkov]

[Abstract] An experimental study of $YBa_2Cu_3O_{7-d}$ high-temperature superconductor ceramic was made concerning the dependence of its mechanical properties on the water content in the original powder. The powder was produced by solid-state synthesis of a $Y_2O_3 + CuO + BaCO_3$ mixture, the water content in it being varied over the 0.2-8 wt.% range by varying the humidity of the atmosphere over the 59-86 wt.% range and appropriately the soaking time. The wet powder was compacted under a pressure of 0.56 GPa at 600°C temperature and then annealed at 920°C for 5 h. The mechanical properties of the ceramic materials were determined on the basis of their Vickers microhardness and their toughness, both properties depending on the phase composition and the microstructure. The microhardness was measured with a PMT-3 tester in air under loads varied over the 10-100 g range and applied for 15 s. As the water content in the powder was increased from 0 to 1.7 wt.%, the microhardness of the ceramic material increased but decreasingly from 4.4 GPa to 5.5 GPa average and evidently not further while its toughness increased from 1.4 $MPa.m^{1/2}$ to 3.1 $MPa.m^{1/2}$ and with a further increase of the water content in the powder. As the water content in the powder was increased beyond 1.9 wt.%, both microhardness and toughness increased at the edges of a specimen while remaining the same at its center. The microhardness, moreover, decreased when the indenter load was increased. Microstructural examination and phase analysis under a scanning electron microscope and in an X-ray microanalyzer have revealed the presence of: 1) $Y_2BaCu_2O_5$, $BaCuO_2$, and $Ba(OH)_2$ phases as well as CuO $BaCO_3$ in addition to the

123-phase in ceramic made from powder with a higher than 2.8 wt % water content; 2) $Y_2BaCu\ O_5$, also CuO, at the upper surface and $BaCuO_2$ at the lower surface of ceramic made from powder with a 2.6 wt % water content. Figures 6; references 12

Structural Perfection of $LaGaO_3$ Single Crystals as New Substrate Material for High-T_c Superconductor Films

927J0284B Moscow SVERKHPROVODIMOST' FIZIKA KHIMIYA TEKHNIKA in Russian Vol 5 No 2, Feb 92 pp 388-399

[Article by A. N. Morozov, Moscow Institute of Steel and Alloys, O. Yu. Morozova, Institute of General Physics at USSR Academy of Sciences, Moscow, and N. M. Ponomarev, State Scientific Research and Planning Institute of Rare Metals Industry, Moscow]

[Abstract] An experimental feasibility study was made concerning the use of $LaGaO_3$ crystals as substrates for Y-Ba-Cu-O and other high-T_c, a preliminary requirement being precise identification of their crystal structure and examination of defects formed in these substrates during film growth. Following synthesis of La_2O_3 and Ga_2O_3 oxides by the solid-phase sintering process, $LaGaO_3$ single crystals were grown by the Czochralski method from iridium crucibles onto rotating (001)-oriented seeds at a rate of 1-2 mm/h in a stream of a 98 percent N_2 + 2 percent O_2 gas mixture. The speed of seed rotation was varied over the 30-40 rpm range as the axial temperature gradient and the radial temperature gradient in the crucible varied over the 30-50°C/cm range and the 50-100°C/cm range respectively. The crystals, 100 mm long and 40 mm in diameter were sliced into substrate disks, the surfaces of these disks then being ground and mechanically polished. Powder diffractograms were recorded in a DRON-2 X-ray diffractometer using a highly asymmetric monochromator cut from a dislocationless intrinsic Ge crystal so as to ensure 333 reflection and an approximately 7° glancing angle for the primary beam. Oscillation curves and two-crystal back-reflection topograms were recorded in a DTS-1 two-crystal spectrometer, one-crystal back-reflection topograms were recorded by the Berg-Barret method in an URT-1 X-ray diffraction topograph. These measurement and calculations have yielded the coordinates of atoms in a unit cell. $LaGaO_3$ crystals belonging in the D(16/2h)-Pbnm space group and the orthorhombic point group. Small shifts of oxygen atoms from the edge centers and of La atoms from the body center in a perovskitic pseudocell have been found to lower the symmetry and quadrupling the volume of a unit cell. The calculation were made by the standard method of minimizing the functional Φ = (sum of N differences between measured and theoretical amplitude of Bragg reflex)/(sum of N measured Bragg reflex amplitudes), N = 35 Bragg reflexes having been measured. Atomic scattering functions (International Tables for X-Ray Crystallography Vol 1: Symmetry Groups, Space Group No 62; Vol 4: Revised and Supplementary Data, Kynoch Press, Birmingham) and the Krivoglaz-Nikiforov approximation were used for estimating the Debye temperature for $LaGaO_3$, this approximation also having been used for estimating the Debye-Waller factors for the various sublattices. Precise measurements of the lattice parameters were made by the Bond method yielding a = 0.548545 nm, b = 0.554018 nm, c = 0.774565 nm, +- 0.000003 nm each. The data are shown to provide a basis for optimization of the X-ray diffractometry of $LaGaO_3$ crystals. With the aid of such data can be and have determined the general characteristics of structural perfection in $LaGaO_3$ single crystals grown by the Czochralski method, of particular interest being the crystallography of twins forming inside these single crystals (also in $NdGaO_3$ and $LaAlO_3$ single crystals). Figures 5; tables 2; references 35

Jahn-Teller Effect in C_{60} Molecules: Possible Cause of Doped Fullerite Becoming Superconductor

927J0286A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 55 Nos 7-8, 10-25 Apr 92 pp 465-468

[Article by V. M. Lokshev, Institute of Theoretical Physics, and E. A. Pashitskiy, Institute of Physics, Ukrainian Academy of Sciences]

[Abstract] The recently discovered superconducting transition at relative high critical temperatures within the 20-40 K range in C_{60} fullerite (crystalline phase of fullerene) is shown to be possibly caused by the Jahn-Teller effect in the C_{60} "buckyball" molecules, these molecules in the A_xC_{60} system (A - alkali metal) having a dense spectrum of vibrational modes and the phonon spectrum of fullerite extending up to frequencies about 2×10^{13} cm^{-1}. It has been found that the critical temperature for doped fullerite will be raised by implanting a dopant element with a larger atomic radius, and that it will be lower under a higher pressure. The proposition is verified for A_3C_{60} compounds with with an f.c.c. crystal lattice, by calculation of the relevant Hamiltonians taking into account electron-phonon interaction in accordance with standard Bardeen-Cooper-Schrieffer theory. It remains still unclear why then no superconducting transition or an only very weak one has been found to occur in A_xC_{70} crystals, whose phonon spectrum is even more abundant. References 6.

Electronic High-T_c Superconductor With Cubic Symmetry

937J0010C Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 55 Nos 9-10, 10-25 May 92 pp 590-593

[Article by V. Ye. Volkov, A. D. Vasilyev, Yu. G. Kovalev, S. G. Ovchinnikov, N. P. Fokina, V. K. Chernov, and K. S. Aleksandrov, Institute of Physics at Siberian Department, Russian Academy of Sciences, Krasnoyarsk]

[Abstract] New high-T_c superconductors have been synthesized which, unlike the known ones with CuO_2 layers in the crystal lattice, include copper oxides with a cubic structure. They were synthesized in two stages. First was synthesized the parent compound $PbSr_2Ca_2Cu_3O_x$, a mixture of $Ca(NO_3)_2$ and $Sr(NO_3)_2$ with CuO and PbO in the proper amounts having been heated to 720°C and held at this temperature for 4-6 h. The specimens of this compound were homogenized by grinding and regrinding in ethyl alcohol. In the second stage of synthesis to one specimen was added a thallium compound only, while to four other specimens were added not only a thallium compound but also a barium compound and a fluorine compound, all in

the proper amounts. Pellets of these new mixtures were homogenized and dried at 105°C, prior to synthesis at 860-870°C within 10-20 min followed by quenching to room temperature. The density of all five thus produced ceramic materials was 5.2 g/cm^3 and their compositions, based on a chemical analysis by the fluorescence method, were: A) $PbSr_2Ca_2Cu_3O_x$ (reference specimen), B) $TlPbSr_2BaCa_2Cu_3O_xF_y$, C) $TlPbSr_2Ba_{2.5}Ca_2Cu_3O_xF_y$, D) $TlPbSr_2Ba_{7.5}Ca_2Cu_3O_xF_y$, E) $TlPbSr_2Ba_{10}Ca_2Cu_3O_xF_y$. A phase microanalysis by the X-ray diffraction method at 300°C revealed only a 2223-phase laminar structure in specimen A, also a new phase with cubic symmetry in specimen B, and only this new cubic phase in specimen C. The composition of this new superconducting phase, constituting about 70 percent of specimen C was found to be $Tl_{0.66}Pb_{0.33}Ba_{0.71}Sr_{1.57}Ca_{2.10}Cu_{3.25}O_{10.2}F_{0.67}$ (the remainder consisting of $Ba_{1-x}Sr_xF_2$ solid solutions along with $BaPbO_3$ and Ca_2CuO_3 phases). Evidently increasing the BaF_2 content in the mixture lowered the 2223-phase content in the synthesized specimens. The new phase could not possibly have an F-centered cell, however, inasmuch as the F-cell in BaF_2 does not admit high-intensity lines such as (201) and (301). The structure of this new phase is best explained by the ability of the BaF_2 structure to form "subtraction" structures (N. V. Belov) and nonstoichiometric solid solutions with heterovalent cations (N. Andersen, K. Klausen, J. Kjenes, J. Schoouman; JOURNAL OF PHYSICS C: SOLID-STATE PHYSICS, Vol 19, 1986). Specimens D and E, with a still higher Ba content, were found to be further depleted of the 2223-phase. Specimen C was tested for the temperature dependence of its electrical resistivity, this being done by the current-voltage method with 5 mA current pulses. Its superconducting transition was found to begin at 117 K and end at 112 K. Its electrical resistivity just above the transition was found to be smaller (6 mΩ.cm) than that of specimen A (within the 100-1000 mΩ.cm range) and to continue to be linearly temperature dependent. Its magnetic susceptibility was measured by the inductive method, with a mutual-inductance bridge and a phase-sensitive detector at a frequency of 1.5 kHz. The temperature dependence of both real and imaginary susceptibility components were found to similar to that characteristic of typical high-T_c superconductor ceramics. Measurement of the thermo-e.m.f. revealed the current carriers to be of the n-type. Figures 3; references 4.

Josephson and One-Particle Tunneling in Superconductors With Charge Density Waves

937J0015A Kharkov FIZIKA NIZKIKH TEMPERATUR in Russian Vol 18 No 7, Jul 92 pp 693-704

[Article by A. M. Gabovich, Institute of Physics at Ukrainian Academy of Sciences, Kiev; UDC 538.945]

[Abstract] Transient tunneling is considered in Josephson junctions with partial dielectrization of the electronic spectrum and with a charge density wave in either one or both of the superconductors, such a superconductor being regarded as one with congruent segments on the Fermi surface where charge concentration waves can form and its Hamiltonian being formulated accordingly. Expressions for its both normal and anomalous Green's temperature functions are obtained by solution of the system of Dyson-Gorkov equations for a system with such a Hamiltonian, considering that the phase and temperature characteristics of the dielectric order parameter Σ are fully determined by elements of the one-particle interband transitions matrix. This parameter is a real quantity in the case of a charge density wave just as in the case of a spin density wave and can be assumed here not to depend on the temperature, inasmuch as the structural transition in such superconductor occurs at a temperature above the critical superconducting transition temperature. On this basis are obtained relations, first for the total current through such a junction in the most general and common case of an insulator film separating two different partly dielectrized superconductors, then also relations for the Josephson current and the quasiparticle current in the special cases of symmetric SD-I-DS and asymmetric SD-I-S junctions. The voltage dependence of these currents is then obtained in an analytical form revealing not only already known logarithmic singularities and steps but also singularities peculiar to partly dielectrized superconductors such as Riedel current jumps at three bias voltage levels corresponding to certain combinations of superconductor gap Δ and dielectric gap Σ. The theoretical results are applied to ceramic high-T_c metal oxides about which relevant experimental data are available: $BaPb_{1-x}Bi_xO_3$ (those with $x \geq 0.35$ completely dielectrized and therefore not superconducting, those with $x < 0.35$ superconducting), $Ba_{1-x}K_xBiO_3$ (those with $x < 0.4$ having charge density waves and not superconducting, those with $x \geq 0.4$ not having charge density waves and superconducting), $YBa_2(Cu_{1-x}Zn_x)_3O_7$, $La_{2-x}Sr_xCuO_4$, also $YBa_2Cu_3O_x$ and $Bi_2Sr_2CaCu_2O_8$. The author thanks A. L. Kasatkin and A. S. Shpigel for discussing the problem and for helpful comments. References 63.

Character of Superconducting Phase Transition in Type II Superconductors

937J0015B Kharkov FIZIKA NIZKIKH TEMPERATUR in Russian Vol 18 No 7, Jul 92 pp 780-781

[Article by I. M. Babin and G. P. Mikitik, Institute of Low-Temperature Engineering Physics imeni B. I. Verkin at Ukrainian Academy of Sciences, Kharkov; UDC 538.945]

[Abstract] The question is considered as to whether appearance of a superconducting phase in a type II superconductor in the absence of an external magnetic field follows a phase transition of the second kind or, owing to interaction of order parameter and vector potential fluctuations, a phase transition of the first kind close to that of the second kind. Only in the Ginzburg-Landau mean field theory and thus only when $|t| >> N_{Gi}$, where $\tau = (T - T_c)$ and N_{Gi} is the Ginzburg number, does the Ginzburg-Landau parameter k determine the sign of surface energy and thus the type of superconductor. While extending this criterion to the critical range of the order parameter ψ, the Ψ theory accounts adequately for fluctuations of the order parameter ψ but not at all for fluctuations of the vector potential A. These fluctuations do not appreciably contribute to the thermodynamics when $|t| > N_{Gi}$ and k_0 (Ginzburg-Landau parameter beyond the fluctuation range) $>> 1$, but they do when $|t| < N_{Gi}$ and fluctuations of the order parameter are also stronger. For an answer to the question, fluctuation of the order parameter treated according to the Ψ theory and the relevant part of the free energy is expressed in the form of a functional (L. N. Bulyavevskiy, V. L. Ginzburg, A. A. Sobyanin; ZHURNAL EKSPERIMENTALNOY I

TEORETICHESKOY FIZIKI Vol 94, 1988) rather than according to the Ginzburg-Landau theory. An analysis of relevant relations and estimates on this basis indicates that the Ψ theory ceases to be applicable in this range and that the hypothesis of change from type II to type I superconductor near the critical temperature has no validity. The same holds true for the analogous nematic → smectic-A transition of a liquid crystal. References 9.

Crossover From Superconductivity to Magnetoresistivity in Cd-Sb Alloy Near Localization Threshold During Temperature Fall

937J0027A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 56 No 6, 25 Sep 92 pp 311-316

[Article by V. F. Gantmakher, V. N. Zverev, V. M. Teplitskiy, and O. I. Barkalov, Institute of Solid State Physics at Russian Academy of Sciences, Chernogolovka]

[Abstract] The superconducting transition in a homogeneous material such as the 43 Cd - 57 Sb alloy near the localization threshold is analyzed theoretically, experiments with this alloy having revealed that the metastable high-pressure phase becomes a metallic phase at liquid-nitrogen temperatures and then a superconducting at about 5.3 K. As the temperature was decreased from room temperature down, a correlation between superconductivity and the conduction mode was detected on the dielectric side of the localization threshold. Initial homogeneity of the material was confirmed by the temperature dependence of the electrical conductivity $\sigma = \sigma(0) + \alpha T^{1/3}$, this relation also found to hold true on both metallic and dielectric sides of the transition. Superconductivity vanished upon change from critical conduction near the metal-to-dielectric transition to hopping conduction in the dielectric state. At a temperature below 1 K superconductivity changed to magnetoresistivity. The authors thank S. I. Dorozhin for assistance with problems in methodology and Ye. G. Ponyatovskiy for interest. Figures 4; references 29.

Superconducting Solenoid for Colliding-Beam Device

937J0024C St.Peterburg ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 62 No 2, Feb 92 pp 146-156

[Article by I. A. Vishnyakov, A. P. Vorobyev, V. F. Kechkin, V. I. Klyukhin, Ye. A. Kozlovskiy, V. Kh. Malyayev, and G. I. Selivanov]

[Abstract] A magnetic system which includes a superconducting solenoid is proposed for the universal calorimetric detector in the UNK 3x3 TeV collider facility. The wide-aperture solenoid in a liquid-He cryostat is surrounded by a catcher, a cylindrical shell between two end shields, and in turn surrounds the cylindrical modular calorimeter structure in a liquid-Ar cryostat as well as the cylindrical modular tracking system. It is designed to ensure highly reliable and stable operations satisfying applicable safety requirements. The catcher serves both as return path for the magnetic flux generated by the solenoid and as terminal part of the hadron calorimeter. The solenoid design, targeted for a magnetic induction of 1.5 T and a not more than about 1 percent deviation from a uniform magnetic field distribution in the central tracking zone, has been optimized and is dimensionally matched with the other detector components. A numerical design and performance analysis of several variants has led to the selection of a solenoid 5.3 m in diameter and 6.36 m long. Calculations were made by using the POISSON Version 3.00 program, based on description Poisson's equation for the magnetic field in the structure including the B-H curve for the catcher material. The central tracking zone is 2.8 m in diameter and 3.2 m long. The main winding has 1410 turns of a conductor designed for an operating current of 5.5 kA. The two corrective coils have each 28 turns of a conductor designed for an operating current of 6.1 kA. All three conductors are transposed cables: 16 strands of insulated 0.5 x 4 mm^2 rectangular CKNT-0.85 superconductor wire inside a flat 99.995 percent pure Al stabilizer sheath. The critical current for the superconductor in a magnetic field of 2.5 T at a temperature of 5 K is 13 kA. The aluminum has a 750-1000 ratio of electrical resistivity at 300 K to that at 5 K. The entire winding is 27.5 km long and weighs 13.3 tons. The inductance of the solenoid is 9 H and its energy storing capacity is 140 MJ. The solenoid draws 1100 kVA during start-up and 630 kVA when operating. It has a protective heat and radiation shield. Auxiliary equipment includes an electric power supply, an automatic monitoring and control system, and the cryostatic-vacuum system. The solenoid is cooled by thermal siphoning and natural convection of the coolant. Cooling it from 300 K to 80 K with 35 tons of liquid nitrogen takes 150 hours, the coolant then circulating at a rate of 200 kg/h. Cooling it from 80 K to 5 K with helium takes 50 hours, the liquid coolant then circulating at a rate of 200 l/h. The cooling system includes two KGU-500/4.5 refrigeration units and a storage tank for liquid helium. The entire structure weighs 67 tons. The authors thank S. P. Denisov for attentiveness and L. S. Shirshov for supplying data on the current-carrying capacity of superconductor wire, also L. V. Kechkina, L. V. Markelenska, and G. V. Romanenko for assistance in writing the manuscript. Figures 6; tables 4; references 9.

Geometry, Topology and Vacuum Energy

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[Article by D. V. Vasilevich and N. N. Shtykov, Leningrad State University]

[Abstract] Recently computations of single-loop vacuum energy have been made for a wide class of models, including scalar, spinor and vectorial fields interacting with gravitation in spaces of the form M^n x G/H, where M^n is a plane n-dimensional space and G/H is a compact homogeneous manifold. Pursuing this field of research, quantum corrections are investigated in multidimensional models in which the internal manifold is an oblate 3-dimensional sphere S^3/Z_p. Specifically, a study was made of single-loop quantum corrections for scalar fields in manifolds which are obtained with the "violation of symmetry" in S^3, that is, with S^3 deformations and factorization for a discrete group. A special section is devoted to the Foch-De Witt-Schwinger expansion for the space SU(2) x U(1)/U(1) x M^4. Two other sections are devoted to the vacuum energy in M^n x R/Z and M^n x S^3/Z_p respectively. A final section deals with summation of topologies and the appearing discrepancies. It was found that the discrepancies arising with summation of topologies disappear when quantum matter is taken into account. References 17: 6 Russian, 11 Western.

Variational Perturbation Theory. Anharmonic Oscillator

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[Article by L. D. Korsun, A. N. Sisakyan and I. L. Solovtsov, Joint Nuclear Research Institute]

[Abstract] A nonperturbative method is proposed for computing functional integrals leading to a series in variational perturbation theory. In this case only Gaussian functional quadratures and those types of diagrams which arise in the standard theory of perturbations are used. In contrast to the asymptotic series in the standard theory of perturbations the variational theory of perturbations series has a finite convergence region. In addition, the presence of free parameters makes it possible to exert an influence on the rate of convergence and thereby to obtain the optimum approximation for the sought-for quantity. An important feature of the proposed approach is the possibility, within its framework, to construct sign-alternating convergent series (series of the Leibnitz type) which make it possible to make bilateral evaluations of the sought-for quantity and the presence of variational parameters makes possible a maximum narrowing of these estimates. Variational perturbation theory in the strong coupling region was used in investigating an anharmonic oscillator, using different approaches for computing its numerical characteristics. It was found that in all the considered cases even the first degree of the approximation gives good agreement with the known precise values. Nonperturbative expressions for vacuum energy, the Green's function and the effective potential are obtained. References 12: 3 Russian, 9 Western.

Scattering of X-Rays by Solitons

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[Article by V. G. Varyakhtar and Ir. V. Varyakhtar, Institute of Metal Physics at Ukrainian Academy of Sciences]

[Abstract] Scattering of X-rays by solitons in solids is analyzed, of interest being one-dimensional sine-Gordon kink-forming solitons in two-dimensional or quasi-two-dimensional crystals such as an adatomic lattice on a metal or graphite substrate surface. Their cross-section for X-ray scattering and the structural form factors are calculated on the basis of the energy Hamiltonian, considering a rhombic adatomic lattice which weakly interacts with a corresponding "plane" substrate lattice. The differential cross-section for elastic scattering of X-rays is obtained directly from the known longitudinal electron concentration profile, whereupon thermal movements are taken into account. For a one-dimensional soliton in an adatomic lattice this is done by considering that the movements here are flexural vibrations, inasmuch as the mass of such a soliton is proportional to the length of the crystal. For a soliton which forms a crowd ion in the atomic chain of a close-packed crystal lattice this is done by considering that its motion here is a random one, owing to its finite effective mass. In the case of weakly elastic scattering of X-rays the center-peak line has a smoother than Gaussian shape and the time form factor is a Lorentzian rather than Gaussian one. Random collisions in this case generate Brownian movements describable by two diffusion coefficients appearing in the equation of soliton distribution kinetics. An analysis of this case in the approximation of small soliton distribution gradients and with a collision integral in the Fokker-Planck approximation reveals the same nature of X-ray scattering and neutron scattering. References 15.

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